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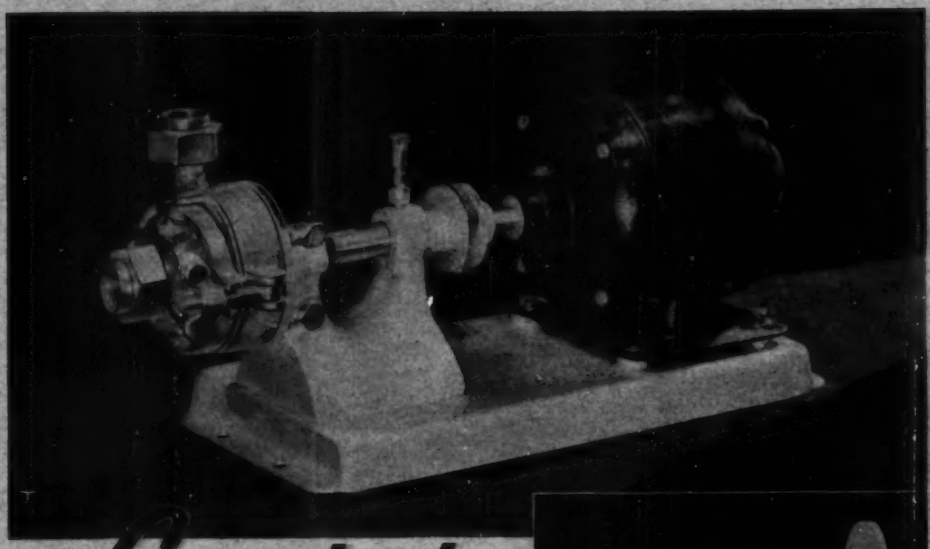

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JOURNAL OF DAIRY SCIENCE

VOLUME XXI JUNE, 1938 NUMBER 6

THE CHEMICAL COMPOSITION AND PROPERTIES OF NORMAL AND RANCID JERSEY MILK

II. FAT, TOTAL SOLIDS AND PROTEIN CONTENT

RUTH REDER

Department of Agricultural Chemistry Research, Oklahoma Agricultural Experiment Station, Stillwater

In a previous paper (6) dealing with milk flavor as related to composition, the chloride and lactose content of rancid milk was compared with that of normal milk from a selected group of Jersey cows. The present paper presents the fat, total solids and protein content of the normal and rancid milk produced by these cows.

Because of the recognized variation in the composition of milk due to such factors as individuality, environment and management, available data could not be used as normal values for the herd under observation. In order to make a direct comparison of the composition of normal and rancid milk at all stages of lactation it was necessary to establish normal values for individual cows and for the whole herd for the entire lactation period. This has been done and the results are reported below.

EXPERIMENTAL

A representative sample of the evening milk from each cow in the herd was taken at weekly intervals. Milk fat and total solids were determined on the Mojonnier. Total protein, casein and albumin were determined by the official methods outlined in the Methods of Analysis of the A. O. A. C. Management of the animals and the method of sampling have been described in a previous paper.

PRESENTATION OF DATA

Fat Content of Normal Jersey Milk

Weekly changes in the fat content of milk from ten cows during a complete lactation are shown by graphs in Figure 1. It is evident from the graphs that the fat of the milk of the individual animal fluctuated appreciably from week to week. The degree of this variation is shown in Table 1

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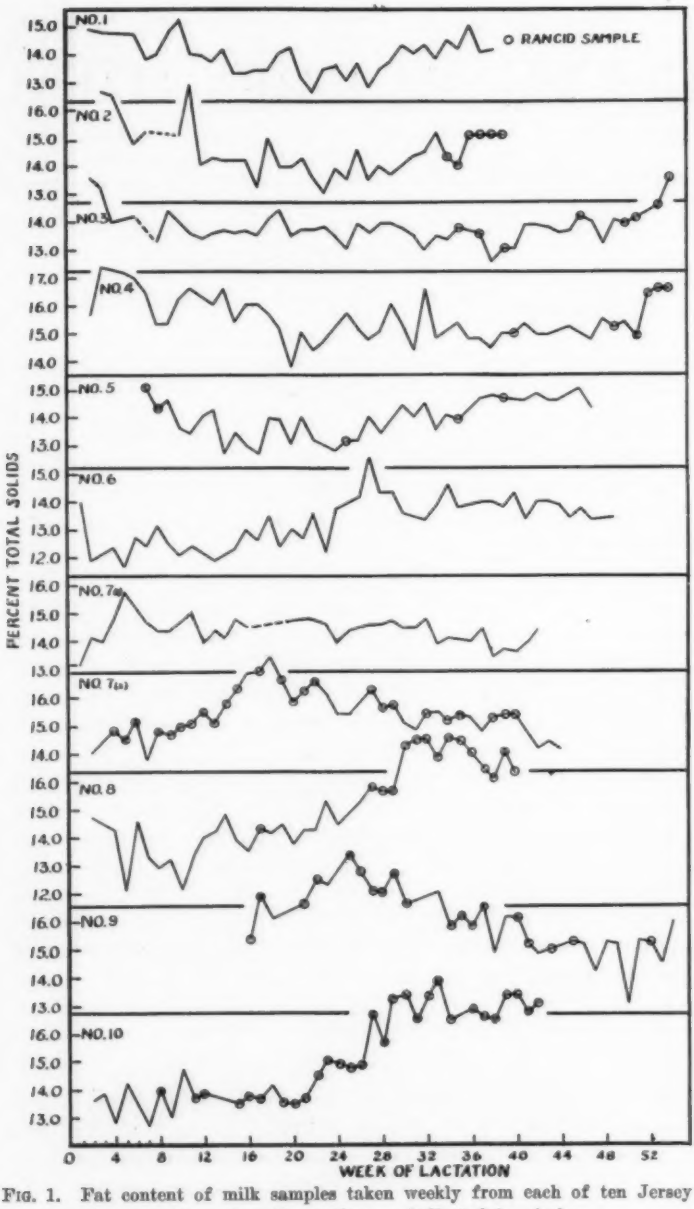

FIG. 1. Fat content of milk samples taken weekly from each of ten Jersey cows during a complete lactation. Rancid samples are indicated by circles.

TABLE 1

Fat and total solids content of normal and rancid Jersey milk produced by ten[1] Jersey cows during a complete lactation

Cow	Milk samples		Fat content					Total solids content				
	Total	Rancid	Mean of normal samples	Mean of rancid samples	Mean of all samples	S. D.[2]	C. V.[3]	Mean of normal samples	Mean of rancid samples	Mean of all samples	S. D.[2]	C. V.[3]
number	*number*	*number*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1	36	0	4.81		4.81 ± 0.08[4]	0.48	10.0	13.96		13.96 ± 0.11[4]	0.67	4.8
2	34	6	5.16	5.12	5.16 ± 0.12	0.67	13.1	14.45	14.77	14.50 ± 0.16	0.91	6.3
3	49	9	4.56	4.95	4.61 ± 0.08	0.55	12.0	13.77	14.00	13.82 ± 0.17	1.23	8.9
4	66	9	5.57	6.83	5.72 ± 0.10	0.83	14.5	15.45	15.86	15.50 ± 0.10	0.81	5.3
5	39	5	5.17	5.24	5.17 ± 0.08	0.48	9.2	13.85	14.19	13.89 ± 0.14	0.88	6.3
6	48[5]	0	4.71		4.71 ± 0.10	0.67	14.3	13.25		13.25 ± 0.13	0.91	6.8
7(1)	36	0	4.98		4.98 ± 0.07	0.42	8.4	14.37		14.37 ± 0.14	0.89	6.2
7(2)	41	25	5.55	5.72	5.65 ± 0.08	0.54	9.5	15.17	15.46	15.34 ± 0.13	0.82	5.4
8	38	12	5.19	7.10	5.84 ± 0.19	1.17	20.1	14.23	16.11	14.82 ± 0.25	1.17	10.6
9	40	22	6.64	7.29	6.98 ± 0.15	0.93	13.3	15.54	16.59	15.96 ± 0.18	1.12	7.1
10	40	29	4.90	6.23	5.76 ± 0.18	1.17	20.3	13.64	15.56	15.04 ± 0.25	1.59	10.5

[1] Two lactations are shown for cow number 7.
[2] Standard deviation.
[3] Coefficient of variation.
[4] Standard error of mean.
[5] Milk criticized as salty during entire lactation.

which presents statistical constants for the mean fat content of the milk of a complete lactation for each of the cows. The mean fat content varied from 4.71 per cent to 6.98 per cent, with coefficients of variation of from 8.4 to 20.1 per cent.

The general tendency for the fat content of milk to decrease during the first weeks of lactation and later to increase is shown in Figure 1; the time of onset of the increase varied with the individual animal. The milk of animal 7 was exceptional in that in both the lactations shown, the fat increased during the first third of the lactation period then decreased slightly as lactation advanced.

Weekly changes in the mean fat content of normal milk of the herd throughout lactation is shown in Figure 2, graph 1. This curve was estab-

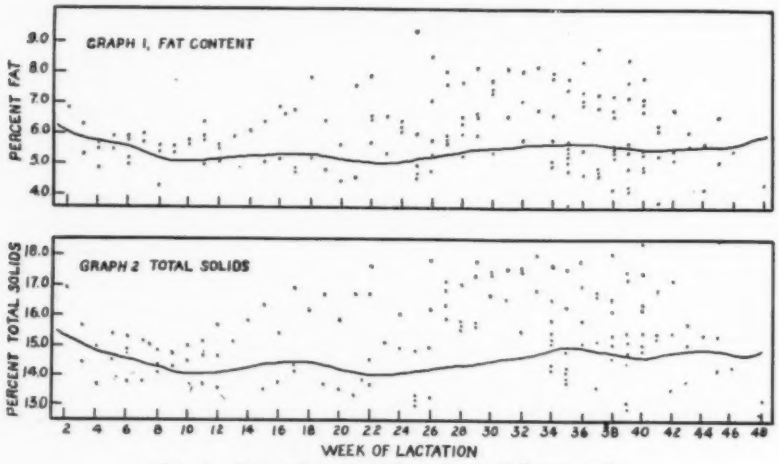

FIG. 2. Fat and total solids content of Jersey milk.

Graph 1

——— Mean fat content of all normal samples for each week of the lactation period.

• Fat content of rancid samples.

Graph 2

——— Mean total solids content of all normal samples for each week of the lactation period.

• Total solids content of rancid samples.

lished by the analysis of 672 individual samples obtained from 20 cows. The general trend of the fat content of milk was marked by a sharp decrease from 6.2 per cent to 5.0 per cent during the first ten weeks of lactation followed by a slow and irregular increase until a fat content of 5.77 per cent was reached in the 48th week.

The above data have been summarized in Table 2 showing the mean fat content of all normal samples for each of 12 four-week periods. The coeffi-

TABLE 2

Fat and total solids content of normal[1] Jersey milk in relation to the period of lactation

Lactation period	Milk samples	Fat content			Total solids content		
		Mean	S. D.[2]	C. V.[3]	Mean	S. D.[2]	C. V.[3]
weeks	*number*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1–4	55	5.72 ± 0.17[4]	1.20	21.9	14.85 ± 0.18	1.36	9.1
5–8	66	5.29 ± 0.12	0.99	18.7	14.43 ± 0.14	1.15	8.0
9–12	57	5.00 ± 0.11	0.77	15.3	14.03 ± 0.12	0.93	6.6
13–16	60	5.20 ± 0.11	0.86	16.4	14.24 ± 0.14	1.10	7.8
17–20	58	5.15 ± 0.11	0.87	16.8	14.27 ± 0.17	1.26	8.8
21–24	61	4.99 ± 0.08	0.67	13.3	14.05 ± 0.13	1.01	7.2
25–28	64	5.20 ± 0.10	0.82	15.8	14.31 ± 0.14	1.08	7.6
29–32	66	5.32 ± 0.11	0.86	16.1	14.50 ± 0.15	1.17	8.1
33–36	54	5.54 ± 0.16	1.13	20.3	14.91 ± 0.20	1.44	9.6
37–40	39	5.36 ± 0.15	0.90	16.9	14.51 ± 0.20	1.25	8.6
41–44	34	5.45 ± 0.13	0.73	13.3	14.71 ± 0.16	0.96	6.5
45–48	20	5.55 ± 0.11	0.48	8.7	14.82 ± 0.23	1.01	6.8

[1] No rancid samples are included.
[2] Standard deviation of mean.
[3] Coefficient of variation of mean.
[4] Standard error of mean.

cients of variation obtained for the fat content of milk from different cows in the same period of lactation were high, ranging, with one exception, from 13.3 per cent to 21.9 per cent, and were somewhat greater than those found for the fat content of the milk of individual animals during a lactation. The average fat content of 672 normal samples was 5.35 ± 0.035 per cent, with a standard deviation of ± 0.912 per cent, and a coefficient of variation of 13.57 per cent.

The decrease in fat content during the first three months of lactation is in agreement with the findings of Van Slyke (7), Eckles (2), Ragsdale (5), and Becker (1), although the drop observed above is somewhat greater than that found by these investigators. The subsequent increase reported by these workers is more regular and slightly greater than was found in the herd under observation. Grady (3), Ragsdale (5), and Becker (1), reported an average fat content of 4.98, 4.98 and 4.605 per cent, respectively, in Jersey milk for the first month of lactation and final values of 5.75, 5.73 and 5.55 per cent, as compared with 5.72 and 5.55 per cent, the initial and final values reported here.

Fat Content of Rancid Samples

A comparison of the fat content of normal milk with that of rancid milk produced during a lactation may be made from the individual graphs in Figure 1 and from the summarized data in Table 1. From these it is evident that the average fat content of rancid samples exceeded that of normal samples from the same animal and that the average fat content of all samples taken during a lactation was higher for animals 7 (2), 8, 9 and 10, frequently producing rancid milk, than for animals 1, 6 and 7 (1), which produced no rancid samples. The average for the former group ranged from 5.65 per cent to 6.98 per cent, that of the latter from 4.71 per cent to 4.98 per cent. It is also of interest to note that during lactation 1 of animal 7, when no rancid milk was produced, the average fat content of the milk was 4.98 per cent, whereas in the succeeding lactation when 61 per cent of the samples analyzed were rancid, the average fat content was 5.65 per cent.

In Figure 2, graph 1, one may compare the fat content of rancid samples with the average fat content of normal milk in the same week of lactation. The tendency is obviously toward a higher fat content in the rancid samples, although many of the values fall within the limits of normal variation as set down in Table 2.

Table 3 shows the average fat content of all normal samples and of rancid samples grouped according to their degree of rancidity and without regard to the period of lactation in which they were produced. The average fat content of the three groups of samples designated as "rancid," "slightly" and "doubtfully rancid" were 6.17, 6.02 and 6.07 per cent, respectively, and were appreciably higher than the mean fat content of 5.35 per cent for all

TABLE 3

Fat and total solids content of normal and rancid Jersey milk

Description of samples	Milk samples	Fat content		Total solids content	
		Mean	Standard deviation	Mean	Standard deviation
	number	*per cent*	*per cent*	*per cent*	*per cent*
Very rancid	5	5.31	0.34	14.96	0.34
Rancid	33	6.17	0.99	15.79	1.25
Slightly rancid	64	6.02	1.40	15.28	1.79
Very slightly rancid	18	5.21	0.53	14.69	1.48
Doubtfully rancid[1]	47	6.07	1.08	15.45	1.38
Rancid (total)[3]	167	5.96 ± 0.09	1.19	15.35 ± 0.12	1.52
Normal (total)	672	5.35 ± 0.04[2]	0.91	14.53 ± 0.02[2]	0.53

[1] Criticized as rancid by less than half the judges.
[2] Standard error of mean.
[3] Total samples scored as having some degree of rancidity.

normal samples. Peculiarly, the few samples described as "very" rancid had a fat content practically the same as that of normal milk.

The average fat content of 167 rancid samples was 5.96 per cent as compared to 5.35 per cent the average of 672 normal samples. The difference between the two values is 0.61 per cent which is 6.2 times the standard error of the difference, ± 0.0986 per cent, and is therefore significant.

Total Solids Content of Normal Jersey Milk

The total solids content of milk paralleled that of the fat content, showing similar fluctuations from week to week. Weekly variation in the total solids content of the milk of individual cows are shown by graphs in Figure 3. The degree of the variations is indicated in Table 1 by statistical constants for the mean total solids content of the milk of the individual cows for an entire lactation. The mean total solids content for the ten animals represented varied from 13.25 per cent to 15.96 per cent, with coefficients of variation ranging from 4.79 to 10.54 per cent, with an average coefficient of 7.29 per cent.

Weekly changes in the mean total solids content of the milk of the herd throughout lactation are shown by graph 2 in Figure 2. The trend of total solids content throughout lactation was the same as that observed in the fat content. During the first 10 weeks the total solids decreased from 14.85 per cent to 14.03 per cent, after which it took an upward trend, interrupted at times by slight drops, reaching a final value of 14.82 per cent in the 48th week of lactation.

The statistical significance of the above data is shown in Table 2 which presents constants for the mean total solids content of all normal samples for each of the 12 four-week periods. Variation in the total solids content of milk of different animals in the same period of lactation was the same as that shown by the individual animal in the course of a lactation. The mean total

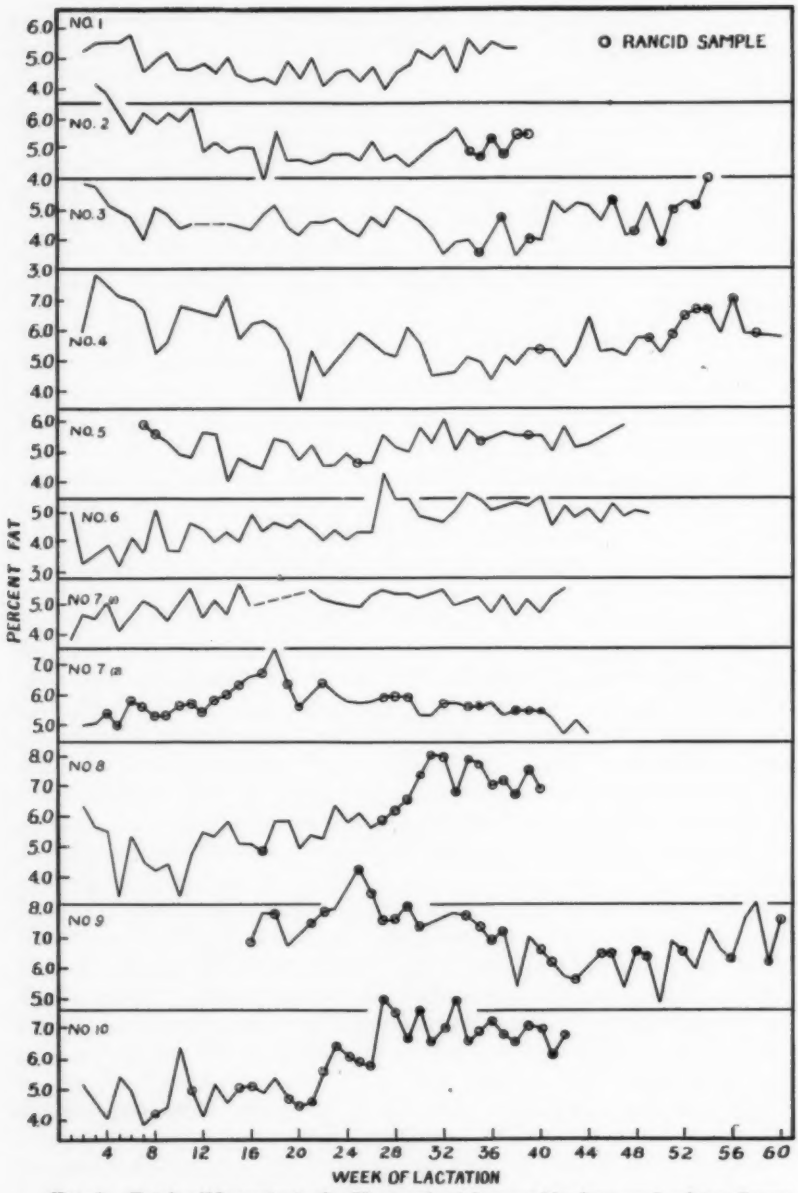

FIG. 3. Total solids content of milk samples taken weekly from each of ten Jersey cows during a complete lactation. Rancid samples are indicated by circles.

solids content of 677 normal samples irrespective of the period of lactation was 14.53 ± 0.0205 per cent, with standard deviation of ± 0.534 per cent and a 3.7 per cent coefficient of variation.

Total Solids Content of Rancid Milk

In Figure 3 the total solids content of rancid samples may be compared with that of non-rancid samples of the same lactation. As is shown in Table 1, the mean total solids content of rancid samples exceeded that of normal samples produced in a given lactation and the average total solids of all samples produced during a lactation was higher for animals that frequently produced rancid samples than for those that did not. The milk of animals 7, 8, 9 and 10, had an average total solids content of 15.29 per cent; that of animals 1, 6, and 7 (1) an average of 13.89 per cent. The average total solids for the milk of animal 7 during lactation 1 when no rancid samples were produced was 14.37 per cent, whereas in the succeeding lactation during which many rancid samples were produced, it rose to 15.34 per cent.

From Graph 2, Figure 2, it is evident that the total solids content of rancid samples was usually higher than the mean total solids content of normal samples produced during the same week of lactation. The average total solids content of 163 rancid samples was 15.35 ± 0.12 per cent; that of 672 normal samples 14.53 ± 0.02 per cent. The difference between the two values, 0.82 per cent, is 6.79 times the standard error of the difference, 0.1207 per cent, and is therefore significant.

Protein Content of Normal Jersey Milk

Determinations were made of the protein content of all samples collected over a period of about four months. A total of 290 samples were analyzed for total protein and of these, 77 samples were analyzed for casein and albumin.

Table 4 presents the average protein content of all normal samples for 12 successive four-week periods. The behavior of protein as lactation advanced was characterized by a decrease from 3.6 per cent in the first month to 3.3 per cent in the second month of lactation, followed by an increase lasting until the 7th month when the protein reached a value of 3.8 per cent which was maintained with little change until the 12th month. Twelve normal samples taken during the 16th to 18th periods were found to have an average protein content of 4.34 per cent. Except for the 4th and 5th months, variation in the protein of samples taken in the same period of lactation was small, the coefficients of variation ranging from 3.67 per cent to 9.21 per cent. There was also little variation in protein of samples from the same animal, the coefficients of variation for 14 individuals ranging from 5.6 to 8.3 per cent. The mean protein content of all normal samples was 3.60 ± 0.02 per cent, with a standard deviation of 0.36 per cent and a coefficient of variation of 9.92 per cent.

TABLE 4

Protein content of normal[1] Jersey milk in relation to the period of lactation

Lactation period	Milk samples	Protein content		
		Mean	Standard deviation	Coefficient of variation
weeks	*number*	*per cent*	*per cent*	*per cent*
1–4	19	3.63 ± 0.07[2]	0.32	8.8
5–8	37	3.33 ± 0.04	0.24	7.3
9–12	35	3.36 ± 0.04	0.23	6.7
13–16	32	3.54 ± 0.08	0.43	12.2
15–20	28	3.61 ± 0.08	0.43	11.9
21–24	23	3.67 ± 0.04	0.17	7.5
25–28	21	3.83 ± 0.07	0.33	8.7
29–32	15	3.76 ± 0.04	0.14	3.8
33–36	9	3.76 ± 0.06	0.18	4.9
37–40	11	3.83 ± 0.11	0.35	9.2
41–44	8	3.85 ± 0.07	0.20	5.1
45–48	6	3.75 ± 0.06	0.14	3.7

[1] No rancid samples are included.
[2] Standard error of mean.

Variations in the protein of milk observed in this study are, in general, in agreement with earlier findings. Nottbohm (4) in a study carried out with one animal observed that protein increased considerably during lactation, a sharp rise occurring after the 36th week. Van Slyke (6) found that the per cent protein dropped from 3.19 per cent in the first month to 2.99 per cent in the second, then began an increase which continued throughout during the entire lactation. The increase became more marked in the tenth and eleventh months. The maximum value observed was 4.04 per cent and was reached in the eleventh month. Eckles and Shaw (2) observed no drop in protein of Jersey milk between the first and second months, but they found that the protein increased after the second month from 3.32 to 4.91 per cent in the last period (56th week). They report an average of 3.64 per cent total protein for the complete lactations of three animals, as compared with 3.60 per cent the average value found for all normal samples in the present study.

Protein Content of Rancid Jersey Milk

During the period in which the protein content of milk was studied, 46 rancid samples were produced. Twelve rancid samples occurring in the first 16 weeks of lactation had a protein content ranging from 2.71 per cent to 3.91 per cent as compared with the normal range of from 3.33 per cent to 3.54 per cent for the same period. Thirty-four rancid samples occurred after the 28th week of lactation; of these, thirty-two had a higher protein content than did normal milk of the same period, the values ranging from 4.0 per cent to 5.32 per cent. The protein content of normal milk of the same period varied from 3.76 per cent to 3.85 per cent.

The average protein content of all rancid samples was 4.13 ± 0.096 per cent, standard deviation ± 0.6511 per cent and a coefficient of variation of 15.8 per cent. The standard error of the difference between the mean

TABLE 5

Total protein, casein and albumin content of normal and rancid Jersey milk

Description of samples	Milk samples	Total protein		Casein		Albumin		Casein	Albumin
		Mean	S. D.[1]	Mean	S. D.	Mean	S. D.[1]	Total protein	Total protein
	number	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Normal	67	3.68	0.559	2.88	0.54	0.35	0.06	78.75	9.41
Rancid	10	4.05	0.359	3.18	0.35	0.39	0.06	78.50	9.53

[1] Standard deviation of mean.

protein content of normal and rancid milk was ± 0.096 per cent; the difference was 0.53 per cent, which is 5.4 times the standard error of the difference and is therefore significant.

Protein Distribution in Normal and Rancid Jersey Milk

Since the total protein content of rancid milk was found generally to be higher than that of normal milk, it seemed desirable to determine whether the increased protein was due to an increase in one or all of the protein fractions. Determinations were made of the total protein, casein, and albumin content of 67 samples of normal milk and 10 samples of rancid milk. The results of these determinations are shown in Table 5. From these results it is evident that casein and albumin are present in the same proportion in rancid milk as in normal milk. One would conclude, therefore, that the increase in the total protein of the rancid samples is due to an increase in all the protein fractions rather than to an increase in any single one.

SUMMARY AND CONCLUSIONS

Data have been presented showing the fat, total solids and protein content of the milk of animals of a Jersey herd, all of which received the same ration and were subject to the same environmental conditions. The amounts of these constituents found in milk criticized as rancid have been compared with the amounts present in normal milk produced during the same period of lactation. The data are presented statistically and graphically both for individual animals and for the herd.

In general, rancid milk has a higher content of total solids, fat and protein than does normal milk of the same period of lactation. The increased protein content of rancid milk is attributed to an increase in the amounts of both the casein and lactalbumin fractions. The high content of these constituents appears to be characteristic of all milk produced by those animals whose milk is frequently rancid.

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INTERRELATIONS OF MILK–FAT, MILK–PROTEIN AND MILK–ENERGY YIELD

W. L. GAINES AND O. R. OVERMAN
Illinois Agricultural Experiment Station, Urbana, Illinois

This article grew out of an inquiry by the American Dairy Cattle Club. In the registration of dairy cattle the Club has taken the progressive step of requiring an estimate of milk-protein yield (in addition to the usual estimate of milk and milk-fat yield) of individual cows. The yield estimates are based on monthly tests covering the 3d–307th days of each lactation, or 305-day partial lactation system.

A recent article by Dr. Goodale (1), geneticist for the Club, represents that protein is the most valuable of all the milk components and that it is desirable, by breeding, to increase the ratio of protein yield to yield of other milk solids (comparable to increasing the proportion of high-priced cuts in meat animals).[1] A breeding program along this line requires a practical field test for protein. Pending the development of such a test the question arises as to the possibility of estimating protein yield from the milk and fat yield.

This question may be put in the form of the relation between fat percentage and protein percentage of the milk of individual cows. If we know the 305-day fat percentage for a given cow, how accurately can we estimate her corresponding protein percentage? The relation between fat and protein (as well as other milk components) for 3-day samples has been heretofore reported (2, 3). It is the purpose of this paper to apply the analyses of these 3-day samples to the appropriate milk yields to secure an estimate for individual cows for a partial lactation approximating the above 305-day period, and to present the interrelation between yields of various milk components, particularly milk fat, milk protein and milk energy.

DATA AND METHODS

The chemical analyses (2, 3) were made on 3-day composite samples of the milk of individual cows in the University of Illinois herd. For the most

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[1] This is a very free version of Goodale's paper, which in fact contains a mixture of legal, economic and biologic points, and unfortunately some misinformation as to milk composition. He states that as we pass from milk of 3 per cent fat to milk of 6 per cent fat the percentage of lactose increases from 4.0 to 4.4 and the percentage of ash increases from .6 to .9. Aside from the gross errors involved in his absolute lactose and ash values it is quite contrary to the well-known principle of osmotic equilibrium in milk secretion that lactose percentage and ash percentage should vary so markedly in the same direction. To maintain a constant osmotic pressure of milk (equal to that of the blood) it is inevitable that variations in lactose percentage and ash percentage will tend to be in opposite directions.

part the samples were taken at 5-week intervals, although there was some variation in this particular. The analysis of each sample included water, fat, protein (total nitrogen $\times$ 6.38), ash and lactose (lactose by difference). In all, 2426 samples were analyzed. Milk yield was determined by weighing each milking.

In the present use of these data the analyses of the first 7 to 11 samples of the lactation have been applied each to an appropriate portion of the continuous milk-yield records (the sample being at approximately the center of the milk-yield portion) to estimate the total milk, fat, protein, lactose, ash and water yield for a period approximating the 3rd–307th days of lactation. The actual length of period represented varies somewhat but is here referred to as 305 days. As thus defined, 305-day partial lactations were available for 130 cows, represented by a total of 1519 samples (out of the 2426 referred to above).

From these 305-day yields the average composition of the milk is derived and presented in Table 1, together with the identity of the cow, the number of samples, length of period represented and average milk yield per day for the period. In the table, 7 to 11 samples indicate a single partial lactation; 16 to 21 samples indicate two partial lactations combined as one; 27 to 32 samples indicate three partial lactations combined as one.

Milk energy is estimated from the equation (4), $E = 93.12f + 53.58p + 39.871 + 49.80a - .356w$, in which E is calories of milk energy per kilogram of milk, f is fat percentage, p is protein percentage, l is lactose percentage, a is ash percentage, and w is water percentage.[2]

RELATION BETWEEN FAT AND PROTEIN

The 305-day fat and protein percentage data of Table 1 are plotted in Figure 1. The correlation between the two is measured by the coefficient of correlation, $r = .755$. Protein is related to fat by the linear equation $p = 2.10 + .346f) \pm .085$, shown by the straight line of Figure 1.

From the standpoint of estimating an unknown 305-day protein percentage from a known 305-day fat percentage by the equation $p = 2.10 + .346f$ applied individually in a large population of cows, the present data indicate that the estimate would be correct within .085 either plus or minus for one-

[2] Since, by the method of analysis, $f + p + l + a + w = 100$, we have the algebraically equivalent equations:

$$
\begin{aligned}
E &= \pm\ 0 + 93.120f + 53.580p + 39.870l + 49.800a - .356w \\
&= +9312.0 \pm 0\ f - 39.540p - 53.250l - 43.320a - 93.476w \\
&= +5358.0 + 39.540f \pm 0\ p - 13.710l - 3.780a - 53.936w \\
&= +3987.0 + 53.250f + 13.710p \pm 0\ l + 9.930a - 40.226w \\
&= +4980.0 + 43.320f + 3.780p - 9.930l \pm 0\ a - 50.156w \\
&= -\ 35.6 + 93.476f + 53.936p + 40.226l + 50.156a \pm 0\ w
\end{aligned}
$$

As a matter of convenience in computation the last one of these equations was used in estimating E. In applying the equation f, p, l and a were used to three decimals instead of the two reported in Table 1.

TABLE 1

Composition of 305-day partial-lactation milk yields of 130 individual cows

Herd No.	Samples	Total period	Milk yield	Fat (f)	Protein (p)	Lactose (l)	Ash (a)	Water (w)	Energy per kg. milk
	No.	ds.	kg.	%	%	%	%	%	cal.
14 Ayrshire Cows									
135	18	595	8.4	3.32	3.13	4.48	.67	88.40	657
326	9	288	18.9	3.46	3.45	4.92	.66	87.51	704
304	9	322	10.6	3.94	3.39	4.52	.69	87.46	732
294	17	584	10.5	3.96	3.65	5.07	.68	86.64	770
74	7	245	11.0	4.00	3.09	4.51	.70	87.70	722
342	9	315	8.7	4.00	3.43	5.14	.68	86.75	763
224	18	645	14.2	4.01	3.57	4.81	.69	86.92	760
354	9	308	8.2	4.18	3.30	4.85	.65	87.02	761
320	9	308	6.1	4.19	3.54	4.56	.67	87.04	764
350	9	315	5.5	4.21	3.49	4.64	.66	87.00	766
321	8	273	7.0	4.37	3.73	4.91	.67	86.32	805
323	18	610	7.9	4.38	3.64	4.91	.70	86.37	802
348	7	245	4.8	4.60	3.65	4.65	.71	86.39	814
351	9	308	7.8	4.96	3.67	5.28	.69	85.40	872
17 Brown Swiss Cows									
510	10	280	18.6	3.38	3.33	5.34	.71	87.24	710
479	10	280	15.3	3.44	3.44	5.02	.75	87.35	711
374	21	602	21.5	3.45	3.17	4.94	.71	87.73	692
499	9	252	12.5	3.50	3.61	5.23	.75	86.91	734
426	19	532	14.8	3.51	3.41	5.10	.69	87.29	717
394	29	826	27.8	3.54	3.37	5.11	.72	87.26	719
427	30	833	21.7	3.62	3.05	5.25	.69	87.39	714
435	20	560	24.4	3.63	3.38	5.19	.71	87.09	730
376	10	287	17.2	3.69	3.39	4.86	.70	87.36	722
393	20	574	13.4	3.90	3.21	5.00	.68	87.21	737
395	10	280	16.2	3.90	3.32	5.37	.69	86.72	759
475	21	581	11.6	3.96	3.44	5.09	.73	86.78	762
404	20	553	9.7	3.99	3.46	5.10	.73	86.72	765
439	32	875	16.2	3.99	3.48	4.99	.74	86.80	763
445	20	559	18.7	4.18	3.51	5.14	.73	86.44	788
401	10	280	18.9	4.28	3.55	5.30	.71	86.16	805
480	11	301	14.3	4.35	3.96	5.00	.78	85.91	824
14 Guernsey Cows									
262	9	309	15.9	4.43	3.40	5.01	.71	86.45	798
284	9	308	16.5	4.49	3.42	5.14	.68	86.27	809
335	9	301	18.4	4.59	3.52	4.94	.73	86.22	818
303	18	631	8.2	4.69	3.64	5.03	.75	85.89	839
282	10	330	10.2	4.72	3.57	5.18	.71	85.82	842
300	18	617	8.1	4.82	3.89	4.99	.74	85.56	863
297	9	309	18.1	4.82	3.83	5.07	.74	85.54	863
271	9	315	7.7	4.86	3.97	5.06	.75	85.36	873
272	10	315	9.7	4.89	3.63	4.97	.69	85.82	852
331	9	301	9.4	5.23	4.06	4.89	.76	85.06	907
267	18	644	7.6	5.27	4.25	4.84	.79	84.85	920
301	19	641	7.6	5.31	4.13	4.94	.77	84.85	921
315	9	308	10.1	5.54	3.89	5.06	.73	84.78	932
270	27	926	8.3	5.74	4.16	4.93	.76	84.41	962

TABLE 1—(*Continued*)

Herd No.	Samples	Total period	Milk yield	Fat (f)	Protein (p)	Lactose (l)	Ash (a)	Water (w)	Energy per kg. milk
	No.	ds.	kg.	%	%	%	%	%	cal.
15 Holstein Cows									
302	9	315	22.7	2.92	3.13	5.10	.65	88.20	644
273	8	308	21.4	3.02	2.99	4.96	.63	88.40	639
254	9	315	28.7	3.04	3.03	4.63	.68	88.62	633
288	9	315	22.7	3.09	3.31	5.11	.66	87.83	671
325	9	295	21.4	3.16	3.46	5.15	.67	87.56	687
263	9	315	29.2	3.19	3.05	4.56	.66	88.54	644
251	9	315	20.5	3.24	2.97	4.82	.67	88.30	654
324	9	302	24.7	3.31	3.25	5.12	.65	87.67	687
200	9	315	17.1	3.36	3.09	4.46	.67	88.42	658
298	19	630	19.0	3.45	3.53	4.86	.70	87.46	708
295	9	315	16.7	3.46	3.38	4.89	.71	87.56	702
322	9	309	18.2	3.50	3.61	5.01	.70	87.18	723
250	8	280	15.5	3.62	3.08	4.92	.67	87.71	700
257	17	624	20.9	3.65	3.29	5.00	.67	87.39	718
296	9	315	13.8	3.67	3.73	4.96	.71	86.93	744
13 Jersey Cows									
333	9	296	18.3	4.37	3.36	4.92	.66	86.69	785
336	9	287	8.6	4.59	3.56	5.19	.69	85.97	829
305	9	312	11.9	4.61	3.59	4.99	.68	86.13	824
279	9	315	10.5	4.68	3.86	5.03	.69	85.74	847
341	9	315	9.6	4.79	3.63	5.32	.70	85.56	857
299	9	349	9.5	4.85	3.77	5.16	.69	85.53	863
313	17	588	11.7	5.00	3.79	4.85	.70	85.66	866
327	19	640	9.1	5.12	3.67	5.09	.68	85.44	880
334	9	308	11.5	5.21	3.88	5.21	.72	84.98	906
317	18	617	9.0	5.32	3.95	5.10	.73	84.90	916
314	9	315	14.0	5.45	4.22	4.89	.74	84.70	935
349	7	238	4.8	5.95	4.12	4.95	.78	84.20	981
347	8	273	4.1	6.00	4.14	5.07	.69	84.10	987
21 Guernsey-Holstein F_1 Cows									
683	9	315	10.4	3.64	3.38	4.68	.73	87.57	712
671	27	938	15.0	3.69	3.42	4.96	.71	87.22	728
665	9	308	17.5	3.81	3.31	4.87	.70	87.31	730
655	9	308	12.8	3.85	3.66	4.78	.77	86.94	752
657	9	301	8.8	3.88	3.45	4.91	.72	87.04	747
663	18	618	16.4	3.93	3.44	4.91	.72	87.00	751
666	9	315	11.0	4.04	3.50	4.77	.76	86.93	760
690	9	301	6.8	4.07	3.66	4.87	.72	86.68	774
680	9	315	10.6	4.13	3.90	5.06	.71	86.20	800
689	9	294	11.5	4.13	3.96	5.28	.73	85.90	814
674	9	308	11.1	4.16	3.82	5.02	.75	86.25	799
673	9	315	16.5	4.19	3.20	5.05	.70	86.86	766
651	9	303	8.5	4.26	3.60	4.68	.71	86.75	781
667	9	308	13.2	4.36	4.06	4.89	.73	85.96	825
668	8	280	10.2	4.37	3.97	4.56	.79	86.31	810
653	7	245	4.9	4.40	4.23	4.53	.78	86.06	825
661	9	301	14.5	4.44	3.45	5.05	.70	86.36	803
688	18	610	10.9	4.75	3.80	5.07	.75	85.63	855
670	19	631	11.2	4.78	3.78	5.02	.73	85.69	854
654	10	315	14.9	4.83	4.01	4.65	.73	85.78	856
659	9	308	11.1	4.93	3.62	5.21	.67	85.57	864

TABLE 1—(*Concluded*)

Herd No.	Samples	Total period	Milk yield	Fat (f)	Protein (p)	Lactose (l)	Ash (a)	Water (w)	Energy per kg. milk
	No.	ds.	kg.	%	%	%	%	%	cal.
25 Guernsey-Holstein F_2 Cows									
723	19	617	9.6	3.66	3.52	4.91	.69	87.22	728
729	9	308	13.3	3.87	3.18	5.15	.66	87.14	738
739	16	553	9.5	3.88	3.33	5.15	.74	86.90	751
738	10	322	8.5	3.89	3.35	4.81	.70	87.25	736
702	10	316	11.9	3.94	3.39	4.69	.72	87.26	740
713	9	315	8.3	3.98	3.53	4.74	.75	87.00	755
736	8	245	10.9	4.04	3.35	4.97	.72	86.92	759
707	9	301	14.3	4.04	3.57	5.15	.69	86.55	776
732	9	308	8.4	4.21	3.63	4.92	.70	86.54	787
705	9	302	12.6	4.22	3.77	5.21	.70	86.10	807
710	7	238	8.1	4.26	3.60	4.64	.75	86.75	781
714	9	308	10.6	4.29	3.83	5.01	.76	86.11	811
730	9	301	11.4	4.38	3.43	4.99	.73	86.47	796
735	10	299	7.4	4.39	3.58	5.05	.70	86.28	806
711	9	309	10.2	4.42	3.55	4.83	.73	86.47	800
724	18	631	10.4	4.43	3.70	5.01	.71	86.15	815
737	9	308	10.2	4.46	3.26	5.08	.69	86.51	797
715	9	309	7.1	4.53	3.93	4.98	.71	85.85	836
728	9	301	10.6	4.55	3.54	5.07	.70	86.14	819
742	9	315	10.4	4.64	3.34	5.25	.77	86.00	828
725	10	308	11.1	4.64	3.64	5.18	.70	85.84	837
726	9	301	11.6	4.69	3.56	5.05	.71	85.99	833
720	9	296	10.5	4.74	3.68	4.99	.70	85.89	842
716	9	302	6.4	4.83	4.13	4.40	.70	85.94	851
734	8	280	11.1	5.23	3.54	4.96	.74	85.53	881
11 Guernsey-Holstein Back-Cross Cows									
806	9	315	10.3	3.26	3.11	5.05	.64	87.94	673
807	9	322	11.2	3.34	3.19	5.11	.68	87.68	688
804	9	315	12.5	3.41	3.22	5.16	.71	87.50	700
801	18	657	11.7	3.43	3.28	5.06	.70	87.53	701
805	9	315	10.5	3.50	3.30	5.32	.68	87.20	718
648	7	259	13.4	3.77	3.50	4.71	.69	87.33	730
802	7	231	8.9	3.91	3.26	4.92	.68	87.23	738
644	9	322	9.9	4.00	3.56	5.31	.67	86.46	778
649	9	295	12.4	4.07	3.39	5.03	.75	86.76	768
803	9	319	11.1	4.48	3.26	5.02	.65	86.59	794
650	7	238	8.8	4.53	3.95	4.60	.78	86.14	825

half of the individuals, while for the other half it would be incorrect by more than .085 either plus or minus. If milk yield were constant at 10,000 pounds the corresponding "probable error" of estimate of 305-day protein yield would be 8.5 pounds. Considering a 305-day protein yield of 300 or 400 pounds it might seem good enough if the estimate is correct within 8 or 9 pounds for half of the individual cows, and correct within 25 or 30 pounds for any individual in the whole population. However, we do not know that the present lot of 130 cows is representative of dairy cows in general, and use of the equation is not recommended, except as an expedient to obtain a rough idea of protein yield.

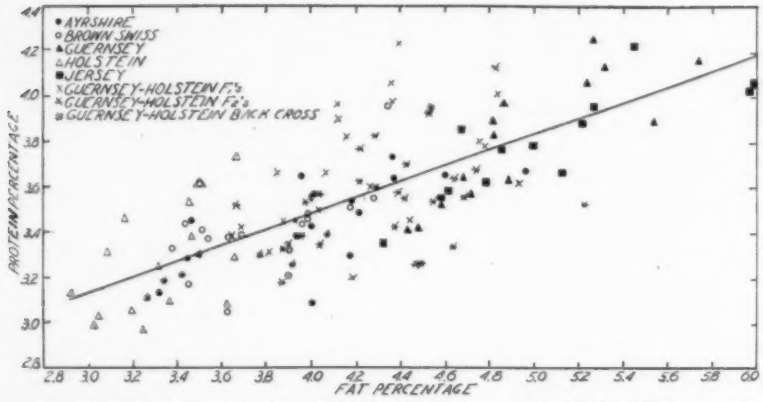

FIG. 1. Per cent protein (p) plotted against per cent fat (f) for 305-day samples of 130 cows. The correlation is r = .755, and the regression equation, represented by the straight line, p = 2.10 + .346f.

In Table 2 the protein-fat percentage equations are given by breed groups, both for the present 305-day samples and the earlier (mixed stages of lactation) 3-day samples. It may be noted from Table 2 that the 305-day protein

TABLE 2

Protein percentage according to breed and fat percentage

Breed	Protein percentage (p) as related to fat percentage (f)			
	3-day samples		305-day samples	
	Equation	p*	p*	Equation
Ayrshire	p = 2.061 + .366f	3.58	3.48	p = 2.257 + .298f
Brown Swiss	p = 1.509 + .523f	3.53	3.41	p = 2.091 + .350f
Guernsey (G)	p = 1.699 + .447f	4.02	3.81	p = .866 + .594f
Holstein (H)	p = 1.100 + .653f	3.42	3.26	p = 1.514 + .527f
Jersey	p = 2.402 + .282f	3.86	3.81	p = 1.590 + .438f
G–H F_1's			3.68	p = 2.112 + .371f
G–H F_2's			3.56	p = 2.481 + .249f
G–H Back Cross			3.36	p = 2.018 + .355f
G–H Cross Bred	p = 1.623 + .499f	3.80		

* At mean fat percentage for the breed.

percentage is lower than the corresponding 3-day protein percentage. As between the several breed groups the protein equations show considerable divergence, the greatest contrast being between the Guernsey, p = .866 + .594f, and the Guernsey-Holstein F_2's, p = 2.481 + .249f. The average of the eight 305-day breed equation constants gives p = 1.87 + .398f as compared with p = 2.10 + .346f for the 130 cows as a single group. In the general equation p = a + bf we are inclined to think it probable that b has a value of about .4, in spite of the fact that it works out at .346 in the particular case of these 130 cows.

RELATION BETWEEN FAT AND ENERGY

In Figure 2 milk energy per kilogram of milk is plotted against fat percentage. The correlation between fat percentage and calories for the 305-day samples of the 130 cows is r = .9847. The relation between these two is much

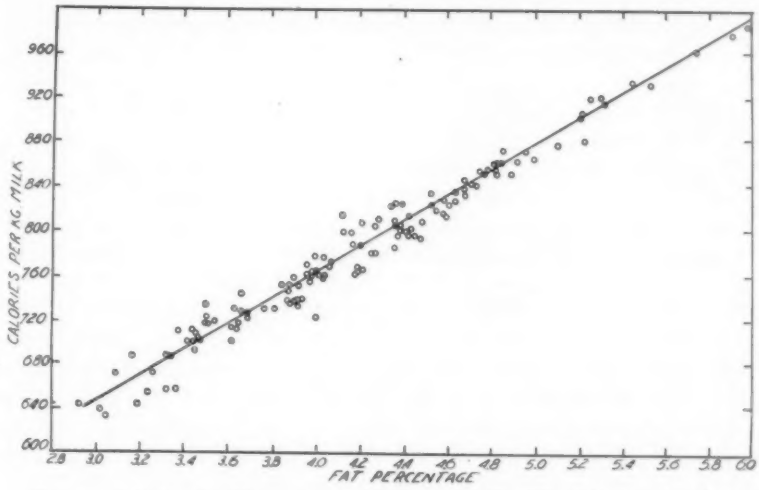

FIG. 2. Calories of milk energy per kilogram of milk (E) plotted against fat percentage (f) for 305-day samples of 130 cows. The correlation is r = .9847, and the regression equation, represented by the straight line, E = 304.8 + 114.1f.

closer than that between fat and protein per unit of milk (r = .755) which is natural since fat itself is a direct and dominating contributor to milk energy, while the connection between fat and protein is indirect.

The regression equation is $E = 304.8 + 114.1f$ or $E = 114.1\ (2.671 + f)$. This compares with the equation previously found (4) from 1999 3-day samples (which did not include the Brown Swiss data) $E = 115.33\ (2.51 + f)$. It may be noted that the present 305-day formula agrees very closely with the estimate of milk energy in terms of 4-per cent milk by the formula $.4 \times \text{milk} + 15 \times \text{fat}$ or 4-per cent milk proportional to $(2\frac{3}{8} + f)$. In terms of calories, however, the present equation gives 761 calories per kilogram of 4-per cent milk in comparison with 751 calories by the older (4) equation. It appears therefore that the formula for estimating 305-day energy yield in terms of 4-per cent milk needs no revision, but to convert a kilogram of 4-per cent milk by the .4M + 15F formula to calories for the 305-day period the factor 761 is indicated, instead of the factor 751 as found from the 3-day samples at mixed stages of lactation.

RELATION BETWEEN PROTEIN AND ENERGY

In Figure 3 milk energy per kilogram of milk is plotted against protein percentage. The correlation between protein percentage and calories for the 305-day samples of the 130 cows is r = .832. The relation between these two is not as close as that between fat percentage and calories (r = .9847) which

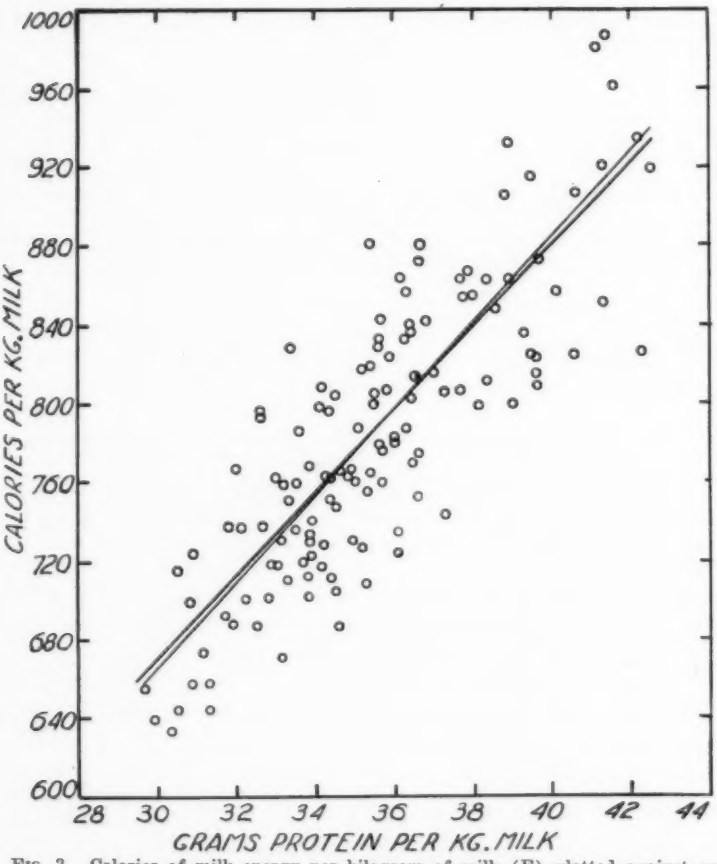

FIG. 3. Calories of milk energy per kilogram of milk (E) plotted against grams protein per kilogram of milk (P) for 305-day samples of 130 cows. The correlation is r = .832, and the regression equation represented by the heavy straight line, E = 37.8 + 21.0P. The light straight line represents the equation E = 22.6P, derived from the means of E and P alone.

may be a reflection of the fact that the protein itself is a smaller contributor to the milk energy than is the fat itself.

The expression of milk energy as a function of the protein (P) of the milk is given in Figure 3 by two equations: $E = 37.8 + 21.0P$ and $E = 22.6P$. The first is the usual least-squares linear regression equation, $y = a + bx$; the second eliminates the a constant or is simply $y = bx$ adjusted by least squares, that is, $b =$ mean of x divided by the mean of y. As may be seen from the plot of Figure 3 there is a very little difference in the accuracy with which the two equations represent the observations. In a gross way fat and energy are more closely related; but in a finer way protein and energy may be more closely related, if one is a simple multiple of the other.

The simple-multiple relation of protein and energy provokes speculation as to the nature of the relationship. If we may say that milk-protein yield is proportional to the nitrogen metabolism of the mammary gland in lactation, and milk-energy yield, to its energy metabolism, then we may advance the thought that the functioning of the gland, as measured by its total energy transformations, is geared to and dependent upon a mechanism of protein growth. This conception fits into the old (discredited) theory that milk formation is accomplished by a process of cell multiplication and disintegration. It may more reasonably be taken to mean that the energy transformations of the milk secreting cell are dependent upon a mechanism of protein elaboration. (In this connection compare the work of Brody, Procter and Ashworth (5) showing that the "basal" energy transformations of various species of animals are proportional to their "basal" nitrogen metabolism.)

By the equation, energy metabolism of lactation = nitrogen metabolism of lactation × constant, we reach the conclusion that without nitrogen metabolism of the mammary gland lactation ceases. The milk of all mammals contains protein, so there is no particular instance of contradiction of this conclusion in nature. On the other hand we do have some particular cases (*e.g.*, the mare) in which the milk is nearly fat free, yet lactation proceeds undisturbed and presumably in accordance with the same protein-energy relation. Taking this fat-free milk as origin we may regard fat-rich milk as the product of the original fat-free mechanism plus an additional one (or acceleration of an original weak one) in which we have a simple multiple relation between fat, protein and energy. Again, we may say that a protein mechanism underlies the energy transformations that result in the formation of milk fat.

The milk-protein yield of dairy cows thus takes on a special significance. Furthermore, if we accept the generalization that, as between individual hard-working cows, milk-energy yield tends to be independent of milk composition, then we may deduce the generalization that milk-protein yield tends to be independent of milk composition. Commercially fat yield has been forced on our attention. Biologically it seems that protein yield is more deserving of attention than is fat yield. After all, however, we have the fortunate circumstance that the total work of lactation can be accurately

estimated empirically from the common determinations of milk and fat dictated by commercial necessity.

PROTEIN/CALORIE RATIO IN RELATION TO FAT PERCENTAGE

While the foregoing section has placed emphasis on a constant protein/calorie ratio this constancy is only approximate. On the basis of the 3-day samples the equations relating protein per calorie to fat percentage have been reported (4) and are here repeated in Table 3 together with the

TABLE 3

Protein colorie ratio according to breed and fat percentage (f)

Breed	P′ = Milligrams of protein per calorie of milk energy			
	3-day samples		305-day samples	
	Equation	P′*	P′*	Equation
Ayrshire	P′ = 56.29 − 2.32f	46.7	45.7	P′ = 58.92 − 3.22f
Brown Swiss			45.9	P′ = 54.77 − 2.34f
Guernsey (G)	P′ = 48.89 − .83f	44.6	43.7	P′ = 40.47 + .66f
Holstein (H)	P′ = 46.49 + .46f	48.1	47.9	P′ = 51.44 − 1.08f
Jersey	P′ = 55.59 − 2.32f	43.6	43.1	P′ = 47.01 − .78f
G–H F_1's			46.5	P′ = 55.35 − 2.09f
G–H F_2's			44.7	P′ = 57.23 − 2.90f
G–H Back Cross			46.3	P′ = 54.62 − 2.19f
G–H Cross Bred	P′ = 49.68 − .61f	47.0		

* At mean fat percentage for the breed.

corresponding equations for the present 305-day samples. In general as fat percentage increases protein per calorie tends to decrease slightly. In the 3-day samples the Holstein breed seemed to be an exception to the general rule. It is therefore of interest to note that in the 305-day samples the exception disappears, and it seems safe to say that for all breeds there is a slight tendency for the amount of protein per calorie to decrease with increase of fat percentage.

BREEDING TO ALTER THE PROPORTION OF PROTEIN

As above noted one object of the American Dairy Cattle Club is to promote the breeding of cows in which the milk protein constitutes a larger proportion of the total food value of the milk. Taking energy as a measure of the total food value of the milk, the object is to increase the protein/calorie ratio. From what has been said this object appears difficult, and perhaps in conflict with the principles of the life processes involved in milk secretion. Still, in Figure 3 it is seen that at a given value of calories per kilogram of milk there is a considerable range in the amount of protein per kilogram of milk. That is, the protein/calorie ratio varies to a certain extent as between the individual cows represented in the present 305-day records.

Of the present records 32 cows have two lactations represented. The correlation between the first and second lactations with respect to the protein/calorie ratio for these 32 cows is $r = .28 \pm .11$. A part of that correlation is associated with the fat percentage and if fat percentage is held

constant the partial correlation reduces to .18 ± .11. If individual differences between dairy cows in the protein/calorie ratio are no more stable than indicated by these low correlations any program of altering the protein/calorie ratio of the milk by selective breeding appears rather hopeless.

SUMMARY AND CONCLUSIONS

The data examined consist of the 305-day partial lactation yields of 130 cows with respect to milk fat, milk protein and milk energy. The yields were determined by continuous milk weights and complete chemical analysis of 3-day samples at 5-week intervals.

Where only the milk yield and fat yield are known milk energy yield may be estimated more accurately ($r = .985$) than can protein yield ($r = .755$). The accuracy of estimate of energy yield from milk and protein yield is intermediate ($r = .832$). These correlations are between actual and estimated yields, at a given milk yield.

While the correlation between fat percentage and energy per kilogram of milk is much higher ($r = .985$) than that between protein percentage and energy ($r = .832$) the protein-energy relation is regarded as the more significant biologically. This point of view is based on the fact that energy yield tends to be a simple multiple of protein yield. If there is no elaboration of milk protein there are no lactation energy transformations and there is no milk secretion. On the other hand, elaboration of milk fat may be zero without interrupting milk secretion. The elaboration of milk fat requires the elaboration of milk protein additional to that of fat-free milk secretion. In general, the total (and often enormous) energy transformations of milk secretion depend on and are proportioned to the elaboration of milk protein or nitrogen metabolism of the mammary gland in lactation.

According to the above interpretation it appears futile to try to modify the protein calorie ratio of milk by selective breeding. The protein calorie ratio has a low variability (C.V. = 5) and as between successive lactations of the same cow it shows a low correlation ($r = .18$). Hence, to increase the proportion of food value (calories) present in the milk as protein, by breeding, would be exceedingly difficult.

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THE pH OF BLUE OR AMERICAN ROQUEFORT CHEESE

S. T. COULTER, W. B. COMBS, AND J. SPENCER GEORGE*
Dairy Division, University of Minnesota, Saint Paul, Minnesota

No data have been found in the literature relative to the pH of Blue or American Roquefort cheese. The only information, known by the authors prior to the data secured in this work concerning the pH of Blue cheese, was furnished by Hall (1). According to Hall's data, the pH of Blue cheese shortly after manufacture was 4.55. The pH dropped to a minimum at about pH 4.45 at the end of about 15 days. During the next 15 days there was a rapid decrease in the hydrogen ion concentration of the cheese to pH 4.70. The acidity decreased slowly but quite uniformly as the cheese aged. When the experiment was terminated at 290 days, the cheese was at pH 5.45.

In the course of other experimental work (2) the authors have determined the pH values on cheese from 60 different lots at intervals during the ripening period. The determinations were made daily for 16 days on the cheese from one group of 12 lots, then at intervals of 3 or 4 days until the 29th day, then weekly until the cheese were wrapped in foil on the 99th day, then again at 180 and 270 days. This group is identified as trial 4. The pH determinations were made on the cheese from the other lots at approximately 4, 40, 70, 100, 180 and 270 days.

The mean pH values for the 12 lots of cheese in trial 4 at the various periods are shown in chart 1. Also shown are the mean pH values for the

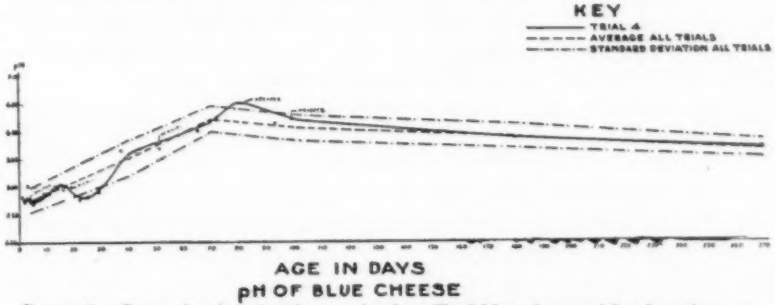

CHART 1. Curve showing the changes in the pH of blue cheese with advancing age.

cheese in all trials at the periods for which data are available. To indicate the variability of the data, the standard deviations of the pH values for the cheese in all the trials are shown.

The hydrogen ion concentration of the cheese appeared to reach a maximum at about pH 4.70 after about 24 hours. After salting, the pH increased

* The data in this paper are from a thesis presented by J. Spencer George in partial fulfillment of the requirements for the degree of M.S., University of Minnesota, Journal Series Paper 1579. Minnesota Agricultural Experiment Station.

rather rapidly until the cheese were pierced to admit air. The data from trial 4 indicate that following piercing, the pH dropped from about 5.0 to about 4.8, but after a few days, the acidity again decreased. The cheese in trial 4 were pierced on the 19th day at which time the mean pH was 5.01. On the 22nd day the mean pH was 4.77. This difference is statistically very significant, as the value of F (ratio of the greater to the lesser mean square) is 37.4. According to Snedecor (3) if the value of F for this number of observations is as great as 7.88 there is only one chance in one hundred that there is no real difference in the data. Every one of the twelve lots of cheese in trial 4 had a lower pH on the 22nd day than on the 19th day.

On the 79th day the mean pH of the cheese in trial 4 was 6.72. This was the maximum pH reached. A gradual re-acidification of the cheese occurred following this period. At 180 days the mean pH was 5.89, and at 270 days 5.72.

The mean pH values for the 60 lots of cheese in all trials followed much the same trend as the cheese in trial 4. The drop in pH following piercing is not evident in the data for all trials as the pH values were not determined between the 4th and the 40th days. The maximum pH recorded for the cheese in all trials was on the 70th day; however, the actual maximum was probably reached as in trial 4, sometime between the 70th and the 100th days.

The cheese in all trials showed the same trend in gradual re-acidification with advancing age as the cheese in trial 4. The mean pH on the 70th day was 6.24, on the 100th day 6.07, on the 180th day 5.91 and on the 270th day 5.69. The value of F in comparing the pH values of the cheese on the 70th day and on the 270th day is 9.68. A value of F as great as 6.84 for this number of observations indicates that there is less than one chance in one hundred that there is no real difference in the data.

SUMMARY AND CONCLUSIONS

1. The acidity of Blue cheese in these trials reached a maximum at about pH 4.7 within 24 hours after manufacture.

2. With the exception of a temporary increase in acidity following piercing, the acidity decreased gradually to about pH 6.5 at about the end of the third month.

3. After about the third month, the acidity of the cheese increased gradually to about pH 5.7 at the end of the ninth month when the experiment was terminated.

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A PLANT STUDY OF DAMAGED AND DEFECTIVE MILK BOTTLES

C. T. ROLAND AND H. A. TREBLER
Research Laboratories, Sealtest, Inc., Baltimore, Md.

In recent years much consideration has been given to the economic and practical importance of broken, damaged, and defective milk bottles. Kouwenhoven (1) reported the results of efforts to improve the resistance of bottles to chipping and recommended a group of tests for bottle quality control. Clement, Bain, and Grant (2) studied bottle breakage from the standpoint of plant design. They found that many bottles were discarded because of chipping and that wide and rapid changes in temperature were important factors in breakage. They concluded that bottle breakage in the plants studied depended to a large degree on the plant arrangement and the equipment used. Jones (3) and Antwerpen, Trebler, and Shrader (4) reported on the factors influencing bottle scratching and etching. Mohr (5) discussed the problem of bottle breakage and bottle loss. Dey (6) reported a plant study of bottle damage in which he concluded that defective new bottles, the washing operation, and improper handling in cases and crates were the chief causes of bottle damage.

These studies have been largely concerned with the effect of plant equipment and handling on bottle breakage. The present study was made to determine the character and source of the defects which render milk bottles unfit for use; the occurrence of defective bottles in the daily cycle of usage; and the relation of retail-wholesale sales distribution to the life of the bottles. Two large milk plants using bottles of different manufacture were selected for the study. About 50% of the quarts used in Plant B were Cream-top style. Plant A used the regular or "straight neck" style exclusively.

I. REJECTED DEFECTIVE BOTTLES

At each point in the plants where defective or broken bottles were picked out, cases were substituted for the cullet cans and the bottles were saved for examination. Paper bags were provided for bottles broken into several pieces. The locations of the bottle collection stations were as follows: (1) return-bottle receiving room, (2) washer inlet, (3) washer outlet, (4) bottle fillers, (5) case filling table, and (6) cold storage room. At the end of the day's operation the rejected bottles were moved to a convenient well-lighted place for a careful examination. A record was made for each bottle showing the bottle manufacturer's name, the year of manufacture, the type of bottle, and the defect which resulted in the rejection of the bottle. A careful study of the bottles resulted in a classification of defects as follows:

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1. *Impact shock*

Impact or mechanical shock damage is identified by the presence or remnant of a scar or shatter spot on the bottle at the point of impact. When the bottle is badly dismembered, as is frequently the case in this type of breakage, the edges of the glass fragments have a rippled or streaked surface which serves further to identify the type of breakage. Spalls and chips are a special form of impact shock breakage resulting from a sharp angular or glancing blow. The plane of fracture is across the surface and not through to the inner surface as in regular impact shock breakage. A spall is essentially a chip in which the flake of glass produced is not entirely severed and clings in place. Some spalls extend deep into the surface. Large spalls are commonly known as "butterflies." Chips and spalls are formed most readily on the peaked and rounded regions of bottles such as lips, shoulders, bottom rims, and bottom ridges. (See Fig. 1.)

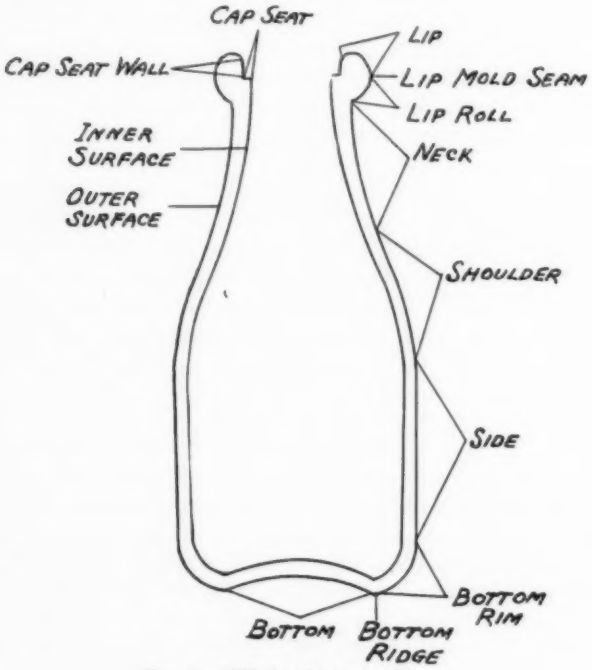

FIG. 1. Milk bottle nomenclature.

2. *Thermal shock*

Thermal shock cracks are non-ragged and curve smoothly. The edges of the glass severed by the crack are free from the ripples or grainy appearance

of impact cleavage. The ends of thermal shock cracks usually fade to a point of invisibility and under some conditions the cracks may appear to shorten and lengthen as the bottles are warmed and cooled. Thermal shock cracks do not always extend from outer to inner surface but may be in either surface and extend only partly through the glass. Fine, almost invisible, thermal shock cracks may require a sudden cooling effect such as cold milk at the filler to open them. Inhomogeneity of the glass composition or abnormal tensions on the bottle surface as a result of improper annealing reduces the bottle's resistance to the normal temperature changes in the washer and at the filler. It is these weakest bottles which crack first when the temperatures are not accurately controlled in the washer. Spalls, chips, and manufacturing flaws may act as nuclei for thermal shock cracks.

3. *Etching*

Etching of bottles is accumulative and results mainly from the continual rubbing together of bottles on the conveyors from washers to fillers. This defect is practically absent from bottles in plants where the bottles average less than 25 trips. Etched bottles are rejected because of their bad appearance.

4. *Manufacturing flaws*

Stones are opaque or transparent particles of foreign material in the glass mass. Bottles containing stones are rejected because of their bad appearance. Stones are usually surrounded by areas of improperly distributed compression or tension and act as nuclei for thermal or impact breakage.

Blisters are large air bubbles near the surface of the glass. Blistered bottles are rejected because of bad appearance and also because the thin wall of the blister is easily ruptured leaving sharp edges and a cavity.

Miscellaneous surface flaws are encountered sporadically in new bottles in significant numbers. They result from inefficient inspection at the glass factory. Bottles with such flaws are rejected because of their bad appearance and their susceptibility to breakage. Occasionally lop-sided or otherwise malformed bottles are encountered which present washing, filling, or capping difficulties and must be rejected.

DISCUSSION OF RESULTS

The damaged and rejected bottles of various sizes picked out at the two plants are classified in Table 1 according to the defect or damage which rendered them unfit for service. It will be seen that spalls and chips occurred most frequently around the lips and the bottom rims of bottles. Bottom ridges were chipped in the small bottles of Plant B largely because of faulty bottle design. In Plant A most of the impact cracking and breakage of the quart size was in the lip and neck. This is probably related to the large

TABLE 1

Classification of defects in rejected bottles

	No. rejected at Plant A (2 days)				No. rejected at Plant B (1 day)				
Type of defect:	*Quart*	*Pint*	*½ Pint*	*Gill*	*Quart*	*Quart**	*Pint*	*½ Pint*	*Gill*
A. Impact shock									
1. Spalled or chipped:									
(a) Lip and/or cap seat	174	10	52	20	97	45	100	82	21
(b) Shoulder	51	3	0	0	11	73	5	3	1
(c) Side wall	10	2	0	0	7	4	0	0	0
(d) Bottom rim	81	15	37	0	29	83	14	6	2
(e) Bottom ridge	0	0	0	0	0	0	6	22	2
2. Cracked or broken:									
(a) Lip and/or neck	212	11	48	71	24	12	15	65	23
(b) Shoulder	23	4	1	0	5	3	1	4	1
(c) Side wall	52	13	27	0	24	74	18	11	0
(d) Bottom rim	46	11	71	1	20	9	14	12	0
(e) Bottom	9	1	0	0	1	0	0	0	0
(f) Completely	114	3	30	9	34	20	21	4	1
B. Thermal shock									
1. Cracked:									
(a) Lip and/or neck	178	18	16	5	9	33	10	27	33
(b) Shoulder	1	0	0	0	0	0	0	0	0
(c) Side	30	1	9	0	7	3	4	5	0
(d) Bottom rim	4	2	0	0	2	2	0	1	0
(e) Bottom	8	1	1	0	0	0	0	0	0
(f) Mfg. flaw	9	1	0	0	0	0	0	0	0
(g) Completely	6	0	6	2	3	0	1	2	2
C. Etched surface	5	0	0	0	3	0	0	1	0
D. Mfg. defects:									
1. Blisters	3	0	1	0	2	2	1	0	0
2. Stones	3	0	0	0	3	6	2	0	0
3. Flaws	18	1	2	0	4	6	3	0	0
Total No. rejected	1,037	97	301	108	285	375	215	245	86
Total No. washed and bottled	240,000	68,000	78,000	10,000	39,500	39,000	49,000	37,500	5,000
Per cent rejected	0.43	0.14	0.39	1.08	0.72	0.96	0.44	0.65	1.72

* Cream-top style.

number of thermal shock cracks in that region. A fine almost invisible thermal shock crack may break open as the result of an impact which in itself would not be sufficiently forceful to damage a perfect bottle. There were many thermal shock cracked quarts and pints at Plant A and many gills at Plant B. This was undoubtedly related to the quality of the bottles used, since each plant had the same kind of washing machines and practically the same temperatures were used.

The small bottles followed the general trend of breakage as shown by the quart bottles. Most of the impact shock damage was in the lip and bottom rim regions and most of the thermal shock damage was in the lip region. In both plants the gill bottles had the highest total rejection percentage. They were followed by quarts, ½ pints, and pints. The low rejection percentage of pints is attributed to their short life as indicated by their low numbers of "trips per bottle." (See Table III). The high rejection percentage of the gills can not be readily explained by the data available.

II. DEFECTIVE BOTTLES IN USE

In order to study the efficiency of the plant bottle inspection at Plant A and to determine if breakage was occurring in the plant, a special sampling was made at the following stations: (1) return-bottle conveyor; (2) at the bottle washer just after the last chlorine water spray; and (3) at the case conveyor entering the refrigerator. One bottle was picked from the same pocket in every sixth quart case at the conveyors, and one bottle was picked from the same place in every sixth row of the sixteen pocket wide quart bottle washer. This sampling provided approximately 1000 bottles representing each station. These bottles were carefully examined and the defects were noted and tabulated.

A summary of the principal defects found in the bottles at the three stations is shown in Table 2. It is interesting to follow the course of the defective bottles in the plant. Bottles defective as a result of impact shock were

TABLE 2

Defects in samples of quart bottles in Plant A

	Empty returned bottles		Bottles in washer		Filled bottles in refrigerator	
	No.	% of sample	No.	% of sample	No.	% of sample
Type of Defects:						
Impact shock	89	9.4	84	9.1	85	8.7
Thermal shock	8	0.8	13	1.5	9	0.9
Mfg. defects	12	1.2	10	1.1	16	1.6
All defects	109	11.4	107	11.7	110	11.2
Size of Sample	954	100.0	910	100.0	981	100.0

reduced in percentage by the rough inspection at the washer inlet. This included principally bottles with broken necks and sides. The inspection at the washer discharge and at the fillers reduced further the impact shock defects. This latter inspection removed some of the bottles with the largest spalls and chips. The thermal shock cracks were increased or opened up by the washing operation and were again reduced by the washer discharge and filler inspection. It appears from these data that impact shock damage occurs largely outside the plant, and thermal shock cracking occurs in the plant. The manufacturing defects seemed to increase as the bottles passed through the plant. This is an inaccuracy resulting from the fact that it is difficult to see some manufacturing defects, notably transparent stones, until the bottle is filled with milk. A significant fact is that most of the so-called "breakage" at various places in the plant does not necessarily occur at the point where the bottle happens to be picked out. One exception is the washer discharge inspection which removes the bottles seriously cracked by thermal shock in the washer.

III. RETAIL-WHOLESALE SALES DISTRIBUTION

In Table 3 is shown the approximate distribution of bottled products from Plants A and B to retail and wholesale sales in comparison with "trips

TABLE 3

Retail-wholesale sales distribution and "trips per bottle"

	Plant A			Plant B		
	Retail %	Wholesale %	Trips per bottle	Retail %	Wholesale %	Trips per bottle
Quarts	92	8	25.7	61	39	12.2
Pints	85	15	9.4	35	65	5.8
Half-pints	57	43*	12.2	8	92*	13.4
Gills	93	7	14.0	38	62	5.4
Weighted Average	87	13	17.2	52	48	8.9

* Includes schools.

per bottle." The data shown as "trips per bottle" were obtained by dividing the number of bottles of each size bottled per month by the number of new bottles of each size purchased per month. This was averaged for the period of 9 months prior to the examinations. There were no bottle deposits required in either case and therefore much bottle loss resulted from the wholesale distribution. "Trips per bottle" is largely dependent on bottle loss outside the plant. It should be noted that school sales are included in the wholesale group. It is a large proportion of the total half-pint sales. The bottle returns from schools are excellent.

SUMMARY

A study of the damaged and defective milk bottles and related data in two large bottling plants resulted in the following conclusions:

1. Bottles were rejected because of impact shock breakage and damages, thermal shock cracks, etched surface, and manufacturing flaws.

2. Spalls, chips, and impact breakage in general occurred most frequently around the lips and the bottom rims of bottle. Sharp edges on the bottles contributed materially to chipping and spalling. Thermal shock cracks occurred most frequently in the lip and neck region. A significant amount of thermal shock cracking occurred in the bottle washing operation.

3. The rejection percentages were in the increasing order: pints, ½ pints, quarts and gills. There was some relation between low rejection and few "trips per bottle." Large percentages of wholesale distribution without bottle deposit were accompanied by few "trips per bottle."

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A DIAGRAMMATIC METHOD OF PRESENTING THE HISTORY OF REPRODUCTION IN A DAIRY HERD

S. W. MEAD

College of Agriculture, University of California, Davis

For many years agricultural colleges and experiment stations have recommended the improvement of feeding methods, the elimination of low-producing cows, and the proper selection of breeding stock. Although this program has resulted in more efficient dairy production, there is still room for considerable improvement.

Low production is responsible for only a small percentage of the total number of cows culled. Many are disposed of each year for other reasons, among which sterility and shy-breeding probably stand out as highly important factors responsible for the large number of replacements required annually in the average herd.

Many cows of great potential producing ability are slaughtered and their desirable effects on the herds lost because of their failure to reproduce. The search for superior germ plasm will improve the dairy cow population but little unless such excellent animals can reproduce normally over a period of years.

In studying[1] the causes of low efficiency of reproduction, we wondered whether certain types of reproductive failure might be diagnosed directly from a study of the breeding and calving records. In the literature, however, we have been unable to find a satisfactory method of analyzing such data. This paper will therefore present a diagrammatic method of assembling breeding data for analysis.

A comprehensive survey of the breeding efficiency of a dairy herd naturally requires, first, a complete and accurate daily recording of all breedings, calvings, and veterinary examinations on an easily accessible form. Breeders commonly enter such data in a hip-pocket note book, listing the services and calvings in chronological order. A few use a method resembling that shown in figure 1. The card, measuring $19\frac{1}{2} \times 17\frac{1}{2}$ inches, will take care of a 40-cow herd. The animals are listed by number in order of age—oldest to youngest. Provision having been made for two calvings, the card need not be renewed oftener than once each year. When any cow has calved twice, a new card is made out, and the cows are again listed in the original order. At birth, heifers are numbered and entered immediately in the proper column. Dates of disposal or purchase are also entered, to the right of the cow number.

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[1] The experimental work reported in this paper became cooperative with the United States Bureau of Animal Industry on February 1, 1937.

UNIVERSITY OF CALIFORNIA—BRANCH OF THE COLLEGE OF AGRICULTURE, DAVIS—DIVISION OF ANIMAL HUSBANDRY

BREEDING AND CALVING SCHEDULE

DATE LOGGED _____ TO _____

COW NO.	DATE OF BIRTH	DATE OF LAST CALVING	DATE TO BREED	BULL TO USE	BREEDING DATES				DATE DUE	DATE CALVED	NO. SEX AND WEIGHT	DATE TO BREED	BULL TO USE	BREEDING DATES				DATE DUE	DATE CALVED	NO. SEX AND WEIGHT

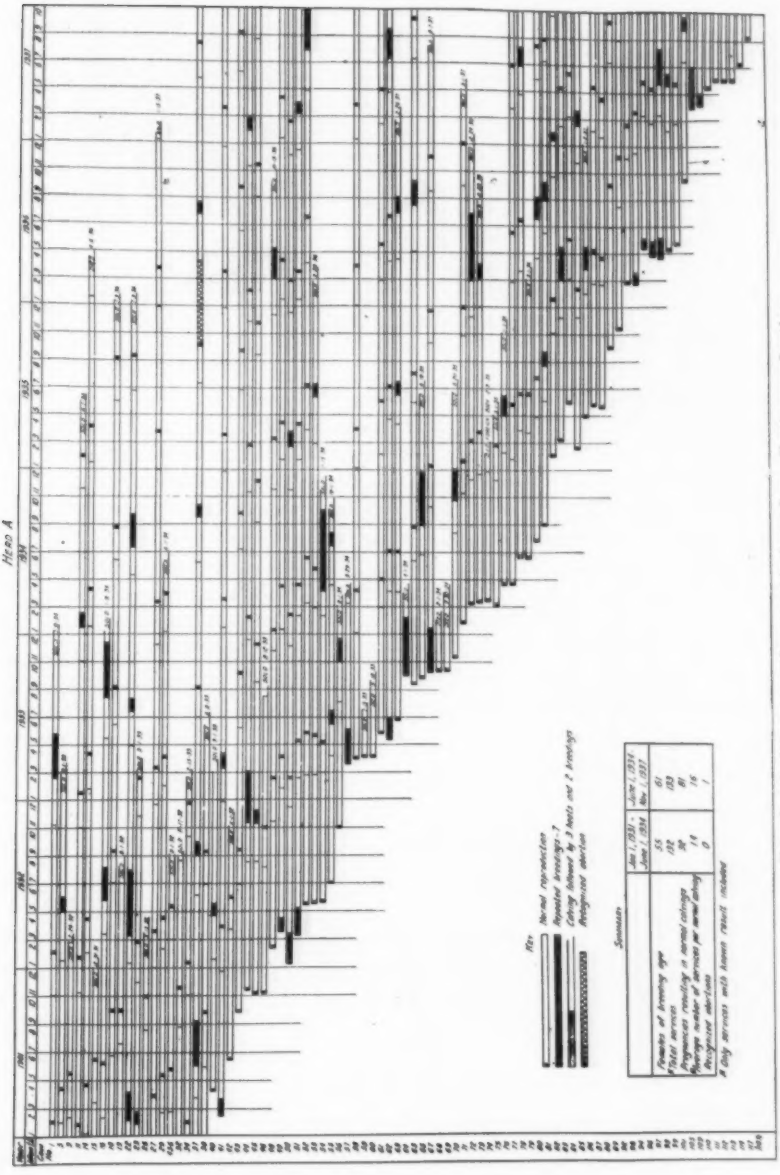
Herd A
Key
Normal reproduction
Repeated breedings - ?
Calving followed by 3 heats not 2 breedings
Pedigreed abortion
Summary
Jan 1, 1931 - June 1, 1934
June 1, 1934 - Dec 1, 1937
Females of breeding age
Total services
Services resulting in normal calvings
Average number of services per normal calving
Pedigreed abortions
Only services with known result included

FIG. 2. A diagrammatic presentation of excellent reproduction.

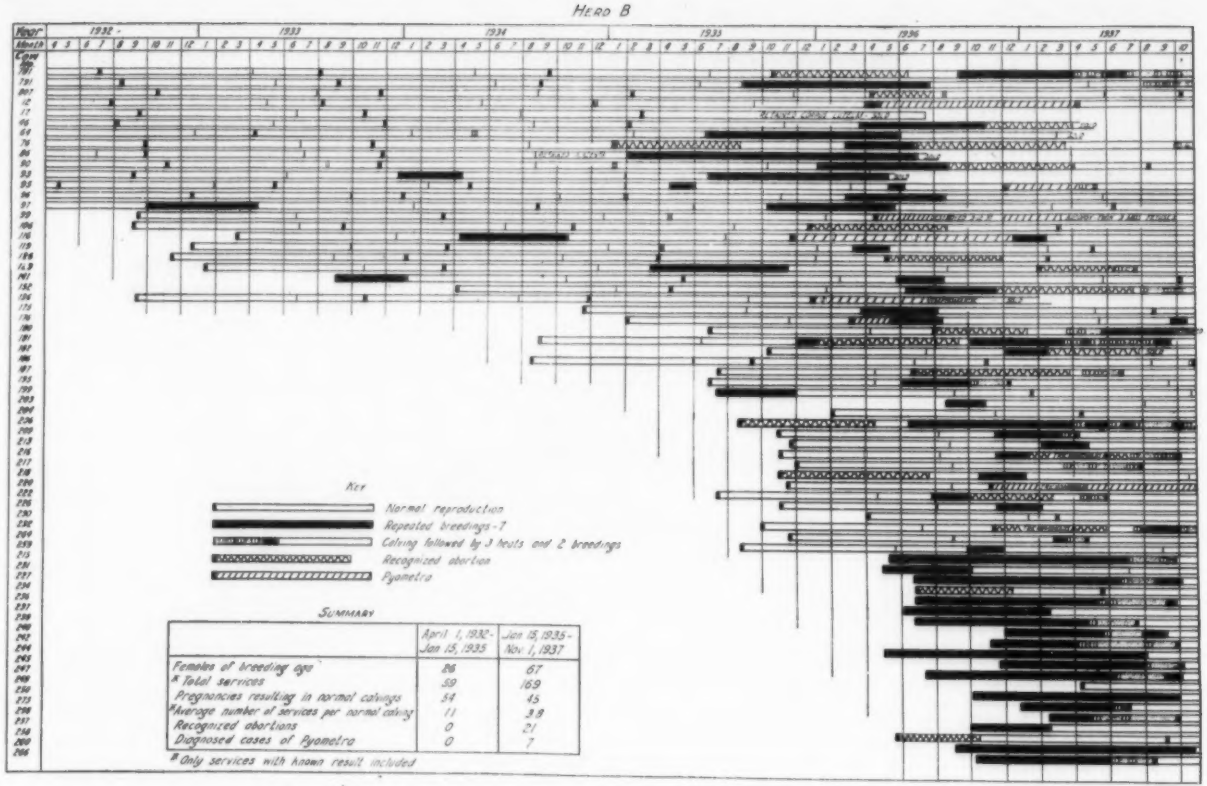

FIG. 3. A diagrammatic representation of efficient reproduction over a period of approximately three years, followed by reproductive failure as a result of Trichomoniasis.

Hence the card serves as an inventory as well as a breeding and calving record. This system has been used in the college herd for fourteen years and by a number of dairymen cooperating with the university in an experimental bull association for ten years. The data when recorded in this manner are readily accessible for analysis.

It is hard to obtain an intelligible picture of the efficiency of reproduction merely through an assemblage of breeding and calving dates. Such data have little meaning when published in tabular form. Figures 2 and 3 attempt to present diagrammatically the histories of reproduction in two California dairy herds.

The former depicts reasonably high efficiency of reproduction, over a period of slightly less than seven years; the latter, normal reproduction for the first 34 months followed by a period of decidedly poor reproduction. The long intervals between breedings, the occurrence of abortions in a herd negative to the agglutination test, and the many cases of pyometra present a typical picture of Trichomoniasis as the probable cause, later verified by actual identification[2] of the organism *Trichomonas fetus* (Riedmiller). After this diagnosis, which took place in March of 1937, the chart shows one phase of the disease-elimination measure—the recording of heat periods.

The diagrammatic method of presenting breeding data is flexible and may be adapted to a number of different types of such data. Reports of veterinary examinations are desirable and often essential. Where more than one sire is in use at a time, identification on the chart may be valuable.

A summary of the data recorded in the diagram is not always necessary, since one may obtain a fairly accurate picture of the situation at a glance. Should such a summary be needed, however, the method used will depend upon the viewpoint and the desired result.

SUMMARY

A diagrammatic method of showing the history of reproduction in dairy herds is presented. The advantages of this method are as follows:

1. The reproductive history of the entire herd, over a long period, may be seen at a glance.
2. The individual performance of each animal can be easily followed.
3. Frequent recordings of data on the chart permit an early diagnosis of abnormal reproduction.
4. The method greatly facilitates the analysis of the data from various angles.

[2] This verification was made by Dr. H. S. Cameron in the Division of Veterinary Science.

COMPARISON OF TRYPTONE–GLUCOSE–SKIMMILK AND STANDARD NUTRIENT AGARS AS MEDIA FOR DETERMINING THE BACTERIAL COUNT IN ICE CREAM[1]

V. D. FOLTZ AND W. H. MARTIN
Kansas Agricultural Experiment Station, Manhattan

Tryptone-glucose-skimmilk agar has been proposed as a more suitable medium than standard nutrient agar for making total bacterial counts on ice cream and milk. What effect the new medium will have on bacterial counts is of vital interest to the ice cream manufacturer who may be required to meet standards which were adopted on the basis of standard agar counts.

A study of 192 samples of commercial ice cream was made by Babel[2] in which he compared standard agar, standard agar plus sucrose, and tryptone agar. He reported that the tryptone agar gave higher total counts for ice cream than did either of the other two agars. The average logarithmic count for all samples on the standard agar was 43,160 and on the tryptone agar, 108,400, or an increase of 151 per cent. The greatest percentage increase was recorded for the low count samples. Babel noted that 28 of the 192 samples gave lower counts on tryptone agar than on standard agar, 83 gave increases of less than 100 per cent, and 81 showed increases of over 100 per cent.

Another comprehensive comparison of the two media was made by Robertson,[3] in which counts on 412 samples of ice cream were made by five different ice cream companies using the standard agar and tryptone agar at incubation temperatures of 32° C. and 37° C.

The logarithmic average of the bacterial counts obtained on standard agar plates incubated at 32° C. was 137 per cent of the counts obtained at 37° C. The average bacterial counts when tryptone agar was incubated at 37° C. and 32° C. were 116 and 154 per cent, respectively, of the counts made with standard agar. Robertson's study was conducted on ice creams with relatively low bacterial counts.

In the study here recorded, 279 samples of commercial vanilla ice cream were analyzed. The samples were collected by the State Dairy Commissioner of Kansas from licensed manufacturers located throughout the state. Prac-

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[1] Contribution No. *173*, Department of Bacteriology and No. *121*, Department of Dairy Husbandry.

[2] Babel, F. J. Significance of Laboratory Tests in the Control of Ice Cream. Ice Cream Trade Journal, 32, 9, 35. Sept., 1936.

[3] Robertson, A. H. The New Proposed Procedure for Making Ice Cream Plate Counts. Report of Proceedings of 36th Annual Convention, Int. Ass'n of Ice Cream Mfgrs., Vol. 2, p. 132. Oct., 1936.

tically all the samples were pint size, factory-filled packages obtained from large wholesale plants, counter freezer operators, and small retail manufacturers. The samples were refrigerated with dry ice, and transported to the laboratory at Kansas State College where the bacterial counts were made. Three plates containing 1/100, 1/1,000, and 1/10,000 dilutions were poured with standard agar and incubated at 37° C. Six plates, two of each dilution, were prepared using tryptone agar, three of which were incubated at 37° C. and three at 32° C. Samples were replated which gave unsatisfactory counts, from the standpoint of number of colonies per plate or discrepancies in counts from the three dilutions.

In Table I the bacterial counts obtained are classified into groups on the basis of the total count on standard agar. The number and per cent of samples falling into each group are indicated. The logarithmic and arithmetic average counts obtained on standard agar have been arbitrarily assigned a value of 100 and counts obtained on tryptone agar at the two incubation temperatures are expressed as percentages of the standard count. The counts are well distributed over a wide range with 57 per cent falling below 100,000 per ml. on standard agar incubated at 37° C.

The logarithmic average counts obtained upon tryptone agar incubated at 37° C. were from 125 to 169 per cent of those obtained on standard agar, the average for all samples being 137 per cent. At the 32° C. incubation temperature the counts varied between 154 and 200 per cent of the counts obtained on standard agar with an average of 192 per cent for all samples (Table I). The arithmetic average counts obtained upon tryptone agar incubated at 37° C. were 142 to 494 per cent of those obtained on standard agar, the average for all samples being 132 per cent. At the 32° incubation temperature the counts varied between 139 and 974 per cent of the counts obtained on standard agar, the average for all samples being 156 per cent (Table I).

As a convenient method of expressing the relationships of the counts, the ratios of the tryptone agar counts to the standard agar counts were calculated by dividing the tryptone agar count by the standard agar count. For example, a ratio of 2.0 would mean that the tryptone agar count was twice that of the standard agar count. These values are presented in Table II. In this table, the relationship of the counts obtained on the different media and at different incubation temperatures is indicated. Sixty-nine per cent of the tryptone agar counts at 37° C. were higher than the corresponding counts on standard agar, whereas at 32° C. 87 per cent of the samples showed higher counts. Comparison of the counts at 32° C. and 37° C. on tryptone agar show that 74 per cent of the samples gave higher counts at the lower temperature. The calculated ratios of tryptone agar counts to the standard agar counts are greater in every instance for the 32° C. temperature than they are at 37° C.

TABLE I

Relationship of tryptone-glucose-skimmilk agar counts to standard nutrient agar counts of 279 samples of ice cream

Range of plate counts	Number of samples	Per cent of samples	Logarithmic averages of standard agar counts (37° C.)	Tryptone agar counts per cent of standard agar counts		Arithmetic averages of standard agar counts (37° C.)	Tryptone agar counts per cent of standard agar counts	
				(37° C.)	(32° C.)		(37° C.)	(32° C.)
Less than 10,000	34	12.2	4,400	125	186	5,000	145	229
10,000–49,999	85	30.5	24,000	148	200	26,500	494	972
50,000–99,999	41	14.7	69,000	145	188	70,700	179	207
100,000–499,999	69	24.7	180,000	133	164	202,000	158	200
500,000–999,999	11	3.9	665,000	135	154	684,500	160	176
1 million to 10 million	25	9.0	2,950,000	169	200	3,652,000	217	276
10 million and over	14	5.0	45,000,000	160	164	100,974,000	142	139
Average all samples	279	100.0	96,500	137	192	5,490,000	132	156

TABLE II

Distribution of increases and decreases in count obtained with various media and incubation temperature combinations and the average ratio of counts for each group

Range of bacteria counts	Number of samples	Tryptone (37° C.) to standard (37° C.)			Tryptone (32° C.) to standard (37° C.)			Tryptone (32° C.) to tryptone (37° C.)			Ratio tryptone (32° C.) / standard (37° C.)	Ratio tryptone (37° C.) / standard (37° C.)
		Higher	Same	Lower	Higher	Same	Lower	Higher	Same	Lower		
Less than 10,000	34	22	2	10	30	3	1	29	1	4	2.2	1.4
10,000– 49,999	85	49	6	30	74	2	9	69	2	14	7.6	3.9
50,000– 99,999	41	33	2	6	38	0	3	30	3	8	2.1	2.0
100,000–499,999	69	51	1	17	61	0	8	49	2	18	2.2	1.8
500,000–999,999	11	6	0	5	9	0	2	9	1	1	1.8	1.7
1 million to 10 million	25	22	0	3	22	1	2	16	1	8	4.6	3.3
10 million and over	14	11	0	3	10	0	4	6	1	7	3.7	2.1
Total number of samples	279	194	11	74	244	6	29	208	11	60		

For the entire group of 279 samples the ratios of the tryptone agar counts at 32° C. to the standard agar counts at 37° C. ranged from 0.15 to 325.0 with an arithmetic mean ratio of 4.11, and a median or middle ratio of 1.52. When comparison was made of the ratio of tryptone agar incubated at 32° C. to that incubated at 37° C. it was found that the ratios ranged from 0.16 to 137.0 with an arithmetic mean ratio of 2.46 and a median of 1.25. The mean ratios are somewhat higher than would be expected due to the influence of a few extremely high ratios. The median ratio gives values which compare very closely with the arithmetic average counts. (These values were obtained from a study of all the assembled data and are not shown in the condensed table.)

DISCUSSION

It is evident from these data that the tryptone agar gave higher average counts at both 32° and 37° C. incubation temperatures in all the various ranges than did the standard agar at 37° C. This is in agreement with the results reported by other investigators except that the percentage increases are not as great as those obtained in other studies. The incubation temperature was an important factor in determining the count on tryptone agar. The change in incubation temperature from 37° C. to 32° C. produced a greater percentage increase in count than that affected by change in the medium. The logarithmic and arithmetic average counts for the various bacterial ranges were not noticeably different. In some of the comparisons which have been made the percentage increase was greater in the higher bacteria ranges than it was in the lower ranges. In this study no attempt was made to determine what type or types of organisms were responsible for the increased counts obtained on tryptone agar; however, a study is now in progress which may give some information on this point.

The ice cream manufacturer who has had difficulty in meeting present standards will be required to exercise even greater sanitary precautions in the manufacture of his product if the tryptone agar and 32° C. temperature are adopted.

SUMMARY

Bacterial counts have been made on 279 samples of commercial ice cream using standard nutrient agar and 37° C. incubation temperature and tryptone-glucose-skimmilk agar incubating the plates at 37° C. and 32° C.

The logarithmic average of the standard agar counts at 37° C. was 96,500 and the counts obtained on tryptone agar at 37° C. and 32° C. incubation temperatures were 137 and 192 per cent respectively of the standard agar count.

The arithmetic average of the standard agar count was 5,490,000 and the counts obtained on tryptone agar at 37° C. and 32° C. were 132 and 156 per cent respectively of the standard agar count.

The mean and median ratios of tryptone agar count at 32° C. to the standard agar count at 37° C. was 4.11 and 1.52 respectively.

The mean ratio of the tryptone agar count at 37° C. to the standard agar count at 37° C. was 2.46 and the median ratio was 1.25.

NOTE

Owing to the fact that this manuscript had been completed before the publication of an article entitled, "The Effect of Using Tryptone-Glucose-Skimmilk Agar and 32° C. Incubation on the Bacteria Count of Ice Cream," M. W. Yale and R. C. Hickey, JOURNAL OF DAIRY SCIENCE, XX, 12, Dec., 1937, it was not included in the review of literature.

THE OLD STORY OF TYPE AND PRODUCTION

LYNN COPELAND

American Jersey Cattle Club, New York

The problem of type and production has been of paramount interest to breeders for generations. The importance of desirable conformation was recognized early by the breeders on the Island of Jersey when the first score card or scale of points was drawn up in 1834. It has also been more than fifty years since the first authenticated butter test was supervised by the American Jersey Cattle Club. During all of this time breeders have constantly striven to improve both the conformation and the producing ability of our dairy cattle.

In 1932, the American Jersey Cattle Club established the Jersey Herd Classification program providing for the inspection and rating of Jersey cows and bulls solely on the basis of conformation. The inspections are made by a group of judges approved by the American Jersey Cattle Club and the cattle are given one of six ratings depending upon their conformation, in relation to the scale of points of the Jersey breed. For instance, a cow to be rated as "Excellent" must be an animal which in the opinion of the official judge would score at least ninety or more on the official scale of points. A cow to be classified "Very Good," must in the opinion of the judge be entitled to a score of approximately eighty-five but less than ninety on the official scale of points. The next rating of "Good Plus" is given to animals scoring approximately eighty but less than eighty-five. The rating of "Good" is bestowed upon animals which in the opinion of the inspector would be entitled to a score of approximately seventy-five but less than eighty points. Cows which in the opinion of the judge are entitled to a score of approximately seventy but less than seventy-five points are rated as "Fair" and all animals which in the opinion of the judge would score less than seventy are rated as "Poor."

In applying for Herd Classification, the owner must submit every registered cow which he owns that has ever calved and all bulls fifteen months of age or older. No exceptions are permitted. The program has grown constantly in favor, since its adoption and to January 1st, 1938, a total of 4818 cows and bulls have been officially classified. The number is now large enough to provide some material for statistical analysis and the ratings and the records of these cows and bulls have been studied in the office of the American Jersey Cattle Club for the purpose of throwing further light on the still important question of type and production.

All of the animals classified have been divided into groups depending

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TABLE 1

Grouping of all animals classified according to age

	Under 2 yrs.	2	3	4	5	6	7	8	9	10	11	12 yrs. and over	Totals
Excellent ..... Cows	0	20	51	37	40	29	28	20	17	21	12	27	302
Excellent ..... Bulls	0	1	8	5	2	6	4	3	3	0	2	4	38
Very Good ..... Cows	0	120	171	142	119	89	65	69	71	53	37	47	983
Very Good ..... Bulls	31	20	19	17	21	6	12	6	3	4	1	7	147
Good Plus ..... Cows	6	284	373	290	241	169	128	85	46	44	27	40	1733
Good Plus ..... Bulls	49	34	17	21	14	9	14	2	8	3	1	2	174
Good ..... Cows	9	261	254	222	139	106	72	60	36	24	15	14	1212
Good ..... Bulls	30	16	4	6	4	6	3	1	1	1	0	2	74
Fair ..... Cows	4	35	39	14	15	10	5	8	3	2	3	4	142
Fair ..... Bulls	0	0	1	0	0	0	0	0	0	0	0	0	1
Poor ..... Cows	0	3	5	1	2	0	0	0	0	0	0	0	11
Poor ..... Bulls	1	0	0	0	0	0	0	0	0	0	0	0	1
Totals ..... Cows	19	723	893	706	556	403	298	242	173	144	94	132	4383
Totals ..... Bulls	111	71	49	49	41	27	33	12	15	8	4	15	435

upon the age at classification and on the ratings given. The results are shown in Table 1.

In examining this table, it will be noticed that there is a decided scarcity of animals in the lower two classification groups. This does not mean that all of the cows of the breed are superior to these lower classifications. However, it is a poor advertisement for any herd to be classified showing a considerable percentage of "Fair" and "Poor" cows. Consequently the usual practice in applying for classification is for the owner to cull the herd in advance and to dispose of the cows of inferior type before the inspection is conducted. As a matter of fact, this stimulant to culling is one of the advantages of the classification program and as a result when the judge arrives at the farm the cows of poor conformation have usually been sold. (It is hoped, to the butcher.)

It is interesting to note that fifty-one per cent of all cows classified as "Excellent" were past six years of age while in the "Good" classification only twenty-seven per cent were six years of age or older and only twenty-five per cent of the "Fair" cows were past six years of age. Apparently, the poorer type cows are soon weeded out of the herds, while the cows of good conformation are retained.

A considerable number of cows which have been classified have also completed official production records either in the Register of Merit or in the Herd Improvement Registry. The records of these cows have been tabulated and converted to a mature yearly equivalent basis using the A.J.C.C. conversion factors. Table 2 shows the records of all the cows that have been classified, grouped according to classification ratings and table 3 shows the same information on the cows classified during the calendar year 1937.

TABLE 2

Production records of all animals officially classified

Classification groups	Number of cows classified	Number of cows with R. of M. or or H.I.R. records	Per cent of cows with records	Average mature production of each group
Excellent	302	228	75.50	650.05
Very Good	983	649	66.09	624.03
Good Plus	1733	991	57.18	602.61
Good	1212	597	49.26	586.97
Fair	142	63	44.37	589.49
Poor	11	1	9.09	556.54
Totals	4383	2529	57.68	608.44

The information in the foregoing tables has been previously published based on a much smaller number of records and attention has been called to the relationship between the ratings of the animals and the production records. It will be observed in examining Table 2, that with the exception of the "Good" and "Fair" groups there is a gradual rise in the production

TABLE 3

Production records of all animals classified during 1937

Classification groups	Number of cows classified	Number of cows with R. of M. or or H.I.R. records	Per cent of cows with records	Average mature production of each group
Excellent	103	57	55.34	634.30
Very Good	379	169	44.59	619.47
Good Plus	649	237	36.52	588.67
Good	455	100	21.98	555.61
Fair	54	17	31.48	578.27
Poor	7	1	14.29	556.54
Totals	1647	581	32.49	596.06

as the classification ratings increase. This increase is not large, but it is very significant that a much greater percentage of the higher rating animals have production records than the lower rating animals. Undoubtedly if an equal percentage of each classification group had been tested the differences in production would be much more pronounced. This very fact makes a detailed analysis of the production records difficult. It seems safe to assume that in general, the animals tested represent the better producers within that group. There were forty-four per cent of the animals rated as "Fair" with production records. Table 4 was compiled on the basis of using records on just forty-four per cent of the cows in each classification group and selecting the cows with the highest records. For example, there were 302 cows classified as "Excellent." Forty-four per cent of this number is 133 and of the 228 "Excellent" cows with records, the high 133 were used and their records averaged. This table is obviously subject to considerable error but it does illustrate that if an equal percentage of each classification group had been tested, the differences in production would be much more pronounced than shown in Table 2 or 3.

TABLE 4

Hypothetical data showing average production when the number of records used is reduced to 44% of the number classified in each group

Classification groups	No. of cows classified	Per cent with records	No. of cows with records used	Average mature production of each group
		Per cent		*lbs.*
Excellent	302	44	133	723.41
Very Good	983	44	433	695.74
Good Plus	1733	44	763	654.75
Good	1212	44	533	613.48
Fair	142	44	63	589.49

It has been suggested that the range in production within each classification group exceeds the differences between the various groups and that therefore the relationship between classification ratings and production is not at

all significant. To determine the range in production of the animals tested in each classification group, the following frequency Table 5 was prepared.

TABLE 5

Frequency table showing distribution of records made by cows classified in various classification groups

Production divisions	Excellent	Very good	Good plus	Good	Fair
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Over 1000 lbs. of fat	0.88	1.69	0.91	0.68	1.59
900 to 999 lbs.	2.63	1.23	2.83	2.01	3.18
800 to 899 lbs.	7.01	7.41	6.26	3.02	3.18
700 to 799 lbs.	22.81	18.05	12.31	14.74	7.93
600 to 699 lbs.	31.14	25.62	24.82	22.28	25.40
500 to 599 lbs.	25.44	26.45	29.07	29.99	31.75
400 to 499 lbs.	8.33	16.05	17.86	19.26	17.46
300 to 399 lbs.	1.75	2.47	5.15	6.87	9.53
Below 300 lbs.	0	0.93	0.81	1.17	0

Examination of this table does illustrate that there is a wide range in producing ability within each classification group. Summarizing the results show that sixty-four per cent of the "Excellent" animals with records are above 600 pounds of fat, fifty-four per cent of the "Very Good" cows exceed 600 pounds, forty-seven per cent of the "Good Plus" cows exceed 600 pounds in production and forty-three per cent of the cows rated "Good" are over 600 pounds. Of the cows rated "Fair," about forty-one per cent exceed 600 pounds in production. However, the variation in production within each classification group is so marked that a classification rating alone is not of a great deal of value in estimating the producing ability of an individual cow. It seems obvious that a single animal cannot be selected from any one classification group with reasonable assurance that the animal selected will be better or worse in production than an individual animal selected from any other group.

In comparing the "Excellent" animals with records with those classified as "Very Good" having records and doing this at random for the entire group, it was found that in fifty-eight per cent of the times, the "Excellent" cows had higher records than the "Very Good" cows. On the same basis, the chances were fifty-six out of one hundred that a "Very Good" cow would have a higher record than a "Good Plus" cow. The chances were fifty-three out of one hundred that a "Good Plus" cow would excel a "Good" cow and the possibility of a "Good" cow exceeding a "Fair" cow in production was fifty-two times out of one hundred chances. The odds on an "Excellent" cow having a higher record than a cow classified as "Good," were found to be about sixty-three to thirty-seven or sixty-three times out of one hundred comparisons, an "Excellent" cow will exceed a "Good" cow in production.

The possibility of any ten animals picked at random in any classification group, excelling any ten others selected at random from a different classifica-

tion group was of interest and such selections were made five times. In making these selections, ten animals were picked at random from each classification group and compared with ten animals picked at random from the other classification groups. The only provision was that no two animals in any one group be by the same sire. The results are shown in Table 6.

TABLE 6

Chart showing average yield of 10 records selected at random from each classification division

Classification	Group 1 (Average of 10 records)	Group 2 (Average of 10 records)	Group 3 (Average of 10 records)	Group 4 (Average of 10 records)	Goup 5 (Average of 10 records)
Excellent	645	663	612	595	718
Very Good	583	617	686	587	688
Good Plus	591	528	509	567	579
Good	557	539	519	585	532
Fair	555	543	603	582	630

It also seemed pertinent to ascertain if the production records of the cows classified were affected by the age at classification. In other words, would animals rated "Excellent" as mature cows be apt to have any higher records than animals rated "Excellent" as immature cows or as old cows past their prime of life. All of the animals classified with production records were divided into three groups. The first group consisted of those cows classified at under five years of age. The second group was composed of animals classified at from five to nine years of age, inclusive, and the third group was composed of cows classified at ten years of age or older. The average production for each age group and for each classification was determined and the results are given in Table 7.

The results shown in this table indicate that age at classification is not a factor affecting the production records of the animals classified. This result was expected for in making the official classifications, the judges are not influenced to any extent by the fact that an old cow may have previously completed an exceptionally high record. The sole guide for classification work is the scale of points of the American Jersey Cattle Club.

It was next determined that a total of fifty bulls have been classified, each having ten or more officially classified daughters. The average score of each bull's daughters was then computed by assigning an arbitrary score of 95.00 for each daughter rated "Excellent," 87.50 for each daughter classified "Very Good," 82.50 for each daughter classified "Good Plus," 77.50 for each daughter rated "Good," 72.50 for each daughter classified "Fair" and a score of 60.00 for each daughter rated as "Poor," in conformation. There were ten bulls rated "Excellent" each with ten or more classified daughters and the average score of all the classified daughters was 85.44 per cent.

TABLE 7

Production records of cows classified at various ages

	Excellent		Very good		Good plus		Good		Fair	
	No.	Av. yield	No.	Av. yield	No.	Av. yield	No.	Av. yield	No.	Av. yield
Cows classified at under 5 years of age	73	658.03	261	634.91	509	603.71	352	585.96	35	570.60
Cows classified at from 5 to 9 years of age	103	653.87	287	616.10	396	599.14	210	590.56	22	625.18
Cows classified at 10 years of age or over	52	632.02	101	615.41	86	614.84	35	580.29	6	570.17
Totals	228	650.22	649	623.57	991	602.93	597	587.26	63	589.62

There were eighteen bulls rated "Very Good," each with ten or more classified daughters, the daughters having an average score of 83.78 per cent. There were twenty bulls rated "Good Plus" in this category and the average score of their daughters was 81.57 per cent. Finally, there were two bulls classified as "Good," each with ten or more classified daughters and the average score of the daughters was 80.72 per cent.

These results may or may not indicate anything. The numbers are entirely too few to be reliable but from the limited number, it does appear as though there might be some relationship between the type or conformation of a bull and the type and conformation of his daughters. However, it must be remembered that in all probability, the better type bulls were bred to better type cows, while the bulls rated in the lower classification groups were probably bred to cows not so good in conformation.

There were also a number of classified bulls that had qualified as "Tested Sires" with ten or more tested daughters. Likewise, a number of the cows classified have qualified as "Tested Dams," each with three or more tested progeny. These bulls and cows were divided into groups, depending upon their classification ratings and the average yields of their tested progeny obtained. The results of this phase of the analysis are given in Table 8.

TABLE 8

Classified bulls and cows qualifying as tested sires and as tested dams

Classification groups	Bulls		Cows	
	Number	Av. yield of tested progeny	Number	Av. yield of tested progeny
Excellent	13	635	9	619
Very Good	17	607	21	607
Good Plus	17	619	38	632
Good	6	706	14	598
Fair	—	—	1	637

In this table also, the numbers are unfortunately too limited to be dependable but it is significant to note that both with the cows and bulls, there does not seem to be any distinct relationship between the classification ratings of the animals and the production of their progeny. There were several bulls and cows in the "Excellent" group with high producing and high classifying progeny. Such animals are the ideals which breeders are seeking and it is on such cows and bulls that breeders must depend for future breed improvement. Obviously, as classification work increases from year to year, further data will eventually be available but until that time, few definite conclusions can be drawn concerning the relationship between the type of an animal and either the type or the production of the progeny.

SUMMARY

In reviewing and summarizing the entire problem, it is very unfortunate that the numbers are so limited and also that an equal percentage of the cows classified in each group were not tested. If every animal classified had an official production record, the conclusions would then certainly be important in adding to our knowledge of breeding better dairy cattle. The results however do indicate that there is definitely some relationship between the conformation of a cow and her producing ability and that both good conformation and high production can be combined in the same animal. They are certainly not inimical to each other. On the other hand, it seems a fallacy to suppose that by breeding solely for production, we may secure ideal breed type or that by breeding solely with type in mind, we can secure the ideals in production. Breeders must continue to select and breed with both ideals in mind and only by following such a practice can our dairy breeds be definitely improved and made more uniform in conformation and producing ability.

SWEETENED CONDENSED WHEY: ITS MANUFACTURE AND PROPERTIES

G. A. RAMSDELL AND B. H. WEBB

Division of Dairy Research Laboratories,
Bureau of Dairy Industry, U. S. Department of Agriculture,
Washington, D. C.

Whey, as a by-product in cheese manufacture, is produced in relatively small quantities in widely scattered factories. A soluble, edible, dry whey can be made in large cheese producing areas where sufficient material is available to operate a spray drying unit. But since whey contains approximately 93 per cent water and is an excellent medium for bacterial growth, it cannot be profitably shipped long distances for processing. The small cheese factory which is not located near a suitable drying plant must either return its whey to the farmer for hog feed or discard it.

Sweetened condensed whey was developed in the hope that it might help to fill the need for a cheap and simple method for preserving whey for human food. The new product is essentially sweetened condensed milk with the casein and milk fat removed.

Sweetened condensed whey has many possible uses in food preparations, but since work on this phase of the subject is still unfinished details will appear in a later paper. The mixture may be added to any food where both whey solids and sugar are desired. It has been used experimentally in fruit jams and whips, certain bakery products, and as an ingredient for several types of candy. Sweetened condensed whey has excellent whipping properties but without flavoring it is not pleasing to the taste. However, with the addition of suitable flavoring material, the product should be useful at soda fountains as a topping for hot chocolate, sundaes, cakes, and similar foods.

EXPERIMENTAL

Work was conducted to determine the feasibility of preserving whey solids with sugar; the optimum quantity of sugar to use; the most satisfactory total solids value for the condensed product; the effect of storage upon viscosity; the value of including butterfat or coagulated whey protein in the concentrated mixture; and finally to investigate any special properties which might enhance the use of the material in food products.

Swiss and cheddar cheese whey and rennet casein whey were available for the work. Cane sugar was used as the preserving agent except where glucose or invert sugar are specifically mentioned. Unless otherwise stated, the whey which was used in all experiments was centrifugally separated to remove the butterfat left in the cheese making process.

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The process of manufacture employed for making sweetened condensed whey was somewhat similar to that used in producing sweetened condensed milk. The whey was pasteurized at 62° C. for 30 minutes, the required quantity of sugar added, and the mixture evaporated in an 18-inch tinned copper pan under 26 to 28 inches vacuum. The condensed product was cooled to 35° C. and stirred for 3 or more hours at room temperature. Very small lactose crystals were essential in the preparation of a smooth product.

Samples of sweetened condensed whey were stored in airtight containers for observation of keeping quality and change in viscosity. Unless otherwise noted, storage was at room temperature, which varied between 25° C. and 30° C.

Viscosity determinations were made with a McMichael viscosimeter at 25° C. Readings were recorded as soon as they remained practically constant. This point was generally reached after the viscosimeter cup had revolved for 5 minutes. Sweetened condensed whey, like many dairy products, developed a structure during storage which partly broke down with stirring. The products were stirred uniformly to adjust the temperature and to secure a representative sample. Some breakdown of structure was inevitable. The figures represent relative rather than true viscosity values but were suitable for comparative purposes. No attempt was made to differentiate plastic from viscous flow.

Apparent viscosity values were calculated in poises from the degrees McMichael on the instrument dial. Wires ranging from No. 18 to No. 30 were used with either the small or large plunger, depending upon the viscosity of the material under investigation. The wires and plungers were calibrated in accordance with instructions furnished with the instrument.

Overrun was determined by whipping sweetened condensed whey with an electrically operated household mixer, using high speed running at 1,000 r.p.m. without a load. Percentage overrun was calculated as 100 times the difference in weight of the same volume before and after whipping divided by the weight after whipping.

RESULTS

Attention was first focused upon the quantity of sugar sweetened condensed whey should contain. Preliminary experiments showed that in the case of concentrated whey with its high salt content, a 58 to 60 per cent sugar/sugar + water ratio was sufficient to retard bacterial growth. The ratio was calculated as follows: Per cent sucrose in sucrose + water = (% sucrose × 100) ÷ (% sucrose + % water). The quantity of sugar necessary to give a product of good keeping quality was low enough to allow considerable latitude in the total solids range of the condensed material. The practical limits for sweetened condensed whey were found to be between 70 per cent and 80 per cent total solids with the optimum at 76 per cent.

The proportion of whey solids to sugar has been expressed as the per cent whey solids ÷ per cent sugar or the W/S ratio. From the W/S ratio and the total solids (W + S) of a sample the percentages of whey solids, sugar, and sugar in water may be calculated. If W + S = 79.2 and W/S = 1.34 (Table 1), then W = 79.2 − S and $\frac{79.2 - S}{S} = 1.34$ and S = 33.8%.

Data given in Table 1 show the effect of increasing the proportion of whey solids to sugar upon the viscosity of sweetened condensed whey. Each

TABLE 1

Effect of variations in the whey solids/sugar ratio upon the viscosity of sweetened condensed whey held at room temperature

W/S ratio	Total solids	Viscosity after 2 months
	Per cent	*Poises*
0.80	80.3	59.0
1.00	78.8	102.1
1.01	79.6	698.7
1.18	79.9	834.3
1.34	79.2	1,677.0

set of figures represents a different batch. The total solids of each run approximates 80 per cent, which is the upper practical limit to which the product may be concentrated. The viscosity figures therefore represent maximum viscosities for each W/S ratio after two months storage. For economical preservation a large W/S ratio was advantageous, but after the viscosity of the mixture exceeded about 800 poises the product became too heavy for general use. The values for the sugar in water concentration of the samples shown in Table 1 ranged from 72.6 per cent for the low whey batch to 61.9 per cent for the product with a W/S ratio of 1.34. If the mixtures had been condensed to 76 per cent instead of 80 per cent total solids, it would have been necessary to increase the quantity of sugar to obtain the same sugar/sugar + water concentration.

From the foregoing considerations it became evident that the simplest and most practical concentration of ingredients for sweetened condensed whey was approximately: Sucrose 38 per cent, whey solids 38 per cent, and water 24 per cent. Such a mixture had a sugar/sugar + water ratio of about 61 per cent. The best manufacturing procedure for this product was as follows:

The total solids content of the fresh whey was determined according to Sanders' formula (1), 0.24 × L + 1.2 × per cent fat, where L = the lactometer reading at 25° C. (Quevenne or Sp. Gr. scale). If the lactometer reading of separated whey was 29.17 then 29.17 × .24 + (1.2 × 0) = 7.0% whey solids. Then to each 100 pounds of fresh separated and pasteurized whey of 7.0 per cent solids was added 7 pounds of cane sugar. The mixture was con-

densed under vacuum to 76 per cent solids. At this point the specific gravity was 1.360 at 50° C. or 1.365 at 40° C. The mixture was cooled to 35° C. and stirred at room temperature for at least three hours. It was then held in sealed containers to prevent mold growth.

After the establishment of the optimum W/S ratio at 1.0 this factor was held constant in most of the subsequent work.

Data plotted in Figure 1 show the rate of increase in the viscosity of fresh sweetened condensed whey as the percentage of total solids was in-

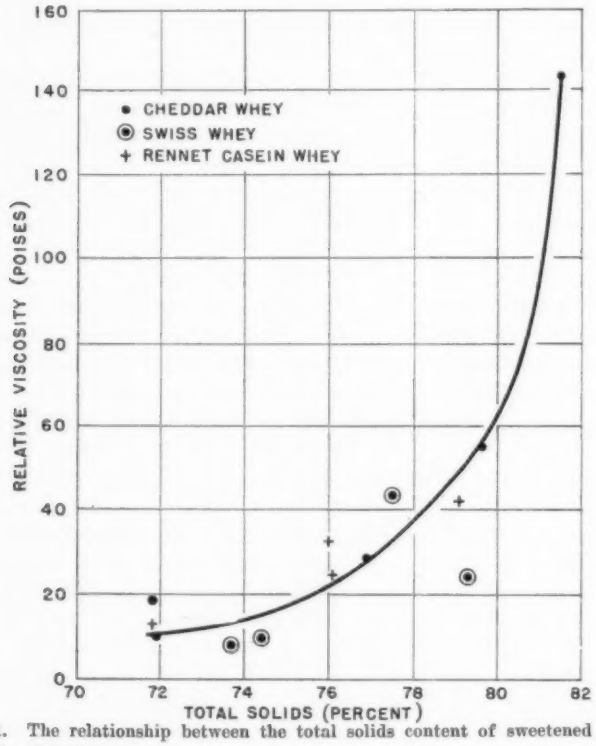

FIG. 1. The relationship between the total solids content of sweetened condensed whey and its viscosity.

creased by evaporation of water. Each point represents a result obtained on a separate batch made from different whey. The distance of some of the points from the curve emphasizes the difficulty which was experienced in obtaining accurate viscosity measurements, but it was felt that the data reflected the true rate of increase of relative viscosity with total solids.

The temperature of pasteurization of whey influenced the viscosity of the condensed product. Data for three temperatures are presented in Table 2.

TABLE 2

Age thickening of sweetened condensed whey pasteurized for 30 minutes at different temperatures

Pasteurization temperature	Total solids*	Viscosity after aging at room temperature			
		2 days	13 days	47 days	116 days
°C.	*Per cent*	*Poises*	*Poises*	*Poises*	*Poises*
55	75.0	17.5	18.9	25.4	44.9
62	74.9	18.4	23.1	26.0	32.1
68	75.8	29.3	27.4	42.1	73.3

* Made from unseparated cheddar whey, the total solids thus including 1.3 per cent butterfat in each case. The whey solids-sugar ratio = 1.0.

The difference in viscosity between samples pasteurized at 55° C. and 62° C. was of little significance. The greater age thickening of the whey pasteurized at 68° C. was probably caused by denaturation of some of the whey protein during pasteurization. When it was important to preserve the original solubility of the protein, pasteurization temperatures of 68° C. or higher were not desirable.

Sweetened condensed whey darkened in color as the temperature or time of storage was increased, but the brown color did not become excessively dark during two or three months storage at room temperature.

The lactose concentration in sweetened condensed whey was approximately 2½ times the amount present in sweetened condensed milk, consequently it was to be expected that a settling of lactose crystals would occur in the whey during long storage periods. The amount of separation, which varied with crystal size and the viscosity of the mixture, was not an important influence upon the quality of the product.

The total solids content of sweetened condensed whey was an important factor in its age thickening. In Table 3 data are given to show the effect of

TABLE 3

*Effect of concentration on age thickening of sweetened condensed whey held at room temperature**

Total solids	Viscosity after aging					Average daily increase
	1 day	7 days	40 days	82 days	142 days	
Per cent	*Poises*	*Poises*	*Poises*	*Poises*	*Poises*	*Poises*
71.9	9.9	18.8	35.4	33.5	33.5	0.17
76.9	28.4	38.8	80.3	121.2	363.3	2.36
81.5	144.1	162.6	894.4	978.2	1257.7	7.84

* Cheddar whey in which the whey solids/sugar ratio = 1.0.

variations in total solids from 71 per cent to 81 per cent upon relative viscosity during aging. The increase in viscosity of the sample containing 76.9 per cent solids was typical of the thickening of most of the batches con-

densed to approximately this concentration. A few samples did not show a uniform viscosity increase during aging while some others (Table 2) did not increase as rapidly as the wheys of Table 3. Although a considerable variation in viscosity development during storage can be anticipated, especially when storage temperatures fluctuate, the normal viscosity increase which develops at cool room temperatures should not detract from the usefulness of the product.

Just as the viscosity of sweetened condensed milk was influenced by storage temperature, so also was this true for that of sweetened condensed whey. However, it was not intended that sweetened condensed whey should require cold storage temperatures, especially since the viscosity which it developed at ordinary temperatures was not detrimental. A thorough investigation of the influence of storage temperature was not made. However, the following figures were considered to represent the increase which would probably be encountered in the viscosity of sweetened condensed whey stored at different temperatures. The figures were obtained from measurements of a whey of 76.9 per cent total solids and a W/S ratio of 1.03. The whey solids included 2.4 per cent of coagulated whey protein added to increase the protein content of the mixture. The holding period was 97 days.

Storage temperature in °C.	Viscosity in poises
Check, not aged	34.0
2	44.9
10	52.0
20	61.4
Room	70.9
37	85.1

The addition of the coagulated whey protein raised the viscosity only slightly above that of most normal batches. While it was not deemed necessary to keep sweetened condensed whey in cold storage to retard an increase in viscosity, it was found desirable to store the product in a cool place to minimize the tendency toward thickening.

Sweet wheys containing butterfat or extra protein were investigated because of the possibility of their use in special food products where quantities of these ingredients were required. However, these additions increased the cost.

Experimental lots of sweetened condensed whey containing butterfat were made. Whey cream was added to give a final fat content of 6 to 14 per cent. This product when condensed to 75 to 80 per cent solids was quite viscous. It remained of good body and flavor during storage at room temperature for three or four weeks, but beyond this time a deterioration in butterfat flavor was noticeable. Some interesting data on the effect of replacing water by butterfat in concentrated sweetened whey are given in

Table 4. The viscosity of condensed whey was greatly increased by the addition of butterfat.

TABLE 4

Effect of replacing water by butterfat on the viscosity of sweetened condensed whey held at room temperature*

Total solids	Butterfat	Solids not fat	Viscosity after 2 months
Per cent	*Per cent*	*Per cent*	*Poises*
73.3	0.0	73.3	6.6
87.0	13.9	73.1	1816.7

* Whey solids/sugar ratio = 0.56.

The presence of small quantities of butterfat in sweetened condensed whey destroyed the whipping properties of the product. When the whey was not separated before condensing, as in the samples mentioned in Table 2, the small percentage of fat kept well during storage but it rendered the product unfit for use where whipping in air was desirable.

Several batches of concentrated whey were made to which extra whey protein was added. Heat coagulated protein was obtained by heating fresh whey and removing the coagulated protein which was at once redispersed by homogenization in a new lot of hot fresh whey. Sugar was added and the mixture condensed in the usual manner. The physical properties of this product were found to be little different from those of the normal condensed material. Data on the viscosity of a batch of this material held at different temperatures have been given above.

Both corn and invert sugar were substituted for part of the cane sugar in sweetened condensed whey according to the requirements of the food product in which the whey was to be used. However, the sucrose could not be entirely replaced by corn sugar because of the limited solubility of dextrose at room temperature. Invert sugar or honey, on the other hand, completely replaced cane sugar to give a sweeter whey, but for most uses only a partial substitution was necessary.

The general principles of the work of Ramsey, Tracy, and Ruehe (2) on the use of corn sugar in sweetened condensed milk were found to apply to sweetened condensed whey. The product became excessively brown during processing and storage when most of the sucrose was replaced by either corn or invert sugar. When dextrose or invert sugar was substituted for sucrose up to 50 per cent a satisfactory sweetened condensed whey was obtained.

One of the most promising features of sweetened condensed whey was the ease with which it could be whipped. The foam-producing whey protein permitted the incorporation of air during whipping while the high viscosity of the product aided greatly in stabilizing the whip.

The increase in volume during the whipping of sweetened condensed

whey of different solids content is shown in Table 5. A whey sample containing 79 per cent total solids was diluted with water to various concentrations and whipped until maximum overrun was attained as determined by the point where further whipping did not incorporate additional air. The

TABLE 5

Effect of total solids upon the whipping properties of sweetened condensed whey. Whey/solids sugar ratio = 1.0

Whipping time at 30° C.	Overrun produced by wheys of different total solids content					
	Total solids content—per cent					
	79	75	70	65	60	50
Min.	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1	84	72	67	101	93	27
2	138	143	127	121	159	
3	179	194	188	191	214	35
4	182*	213*	229	240	293	
5	179	213	254	281	340	39
6			259*	300*	358	
7			259	300	368*	43
8					368	
9						46
11						54*
* Stability of whip at maximum overrun. Temperature 28°–30° C.						
	Min. 3600	*Min.* 910	*Min.* 205	*Min.* 130	*Min.* 70	*Min.* 0

stability of the whips also is given in Table 5. This was determined as the time when the first drainage appeared in the bottom of a 150 cc. glass filled with whipped material.

It was not possible to obtain a stable whip when the total solids were 50 per cent. This mixture was too low in viscosity to have even slight stability. The sample containing 79 per cent solids was the most viscous and showed the greatest stability. The highest overrun was produced by the 60 per cent solids sample which was thin enough to allow an easy incorporation of air and at the same time viscous enough to hold it, at least for a short period.

For practical considerations it may be said that aging does not significantly influence the whipping properties of sweetened condensed whey.

The data of Table 6 show that approximately the same maximum overrun was finally obtained during whipping regardless of the aging period with its accompanying increase in viscosity. These data seem to indicate again that the increase in viscosity with age was largely an increase in apparent viscosity, hence the difficulty experienced in securing accurate viscosity measurements. As the aging period progressed and the viscosity increased (Table 6), the overrun for the first two minutes of whipping showed a de-

TABLE 6

*Effect of aging upon the whipping properties of sweetened condensed whey**

Whipping time	Overrun after different aging periods			
	Fresh	28 days	51 days	73 days
Min.	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1	113	101	105	98
2	202	191	174	172
3	235	229	229	238
4	248	249	232	259
5	238	225	230	242
Viscosity of aged samples before whipping				
Poises	*Poises*	*Poises*	*Poises*	
9.4	17.9	35.4	49.6	

* Aged at room temperature. Measurements at 25° C. Whey solids/sugar ratio = 1.0. Total solids = 74.4 per cent.

crease. Apparently about two minutes of vigorous whipping was required to beat out the temporary viscosity which had developed.

Investigation was made of the effect of heating to various temperatures upon the whipping properties of sweetened condensed whey. Five hundred gram samples of 76 per cent solids sweetened condensed whey were heated to 70° C., 80° C., 90° C., and 95° C. for 5 minutes. The water loss was replaced, the samples cooled to room temperature and held at 23° C. for 24 hours with occasional stirring to recrystallize the lactose. The wheys were then whipped to their maximum overruns in 4 minutes for the unheated check and in 3 minutes for the heated samples. The overruns obtained were: Check, 144 with 180, 153, 147, 171 per cent in the order of increasing temperatures of heating. The whipped check sample showed its first drainage in 3 days, the 95° C. sample not until 5 days, with the others falling between these times. The data indicate that heat coagulation of the soluble whey protein is not detrimental to the whipping properties of the sweetened condensed product. Evidently the whipping properties of this material are dependent upon its high viscosity and, at least partially, upon a non-heat coagulable foam-producing material identical perhaps with that described by Ansbacher, Flanigan and Supplee (3).

SUMMARY

1. Whey solids were simply and inexpensively preserved in a form directly utilizable in sweet foods by condensing a mixture of fresh whey and sugar.

2. The most satisfactory procedure was to add to separated, pasteurized whey a quantity of sugar equal to the weight of the whey solids. The mixture was condensed under vacuum to 76 per cent total solids, cooled to 35°

C. and stirred for at least 3 hours to produce small lactose crystals. It was sealed in airtight containers.

3. The effects of manufacturing processes, of concentration of ingredients, and of storage conditions upon the relative viscosity of sweetened condensed whey were determined.

4. Sweetened condensed whey kept well during storage at room temperature for at least 3 months. The changes during such a storage period were a slight darkening in color and a small increase in viscosity. Holding at cool temperatures minimized the changes which occurred during storage.

5. Sweetened condensed whey was easily whipped to an overrun of approximately 200 per cent in 4 minutes. The whip was stable for 15 hours. The relationship between total solids content, overrun, and stability of whip was investigated.

ACKNOWLEDGMENT

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SOME EFFECTS OF A VITAMIN D DEFICIENCY ON MATURE DAIRY COWS

G. C. WALLIS
Dairy Department, South Dakota State College, Brookings, S. Dak.

The important role played by vitamin D in preventing disease and promoting the efficient utilization of calcium and phosphorus by calves and young cattle has been established by the numerous experiments on this problem which have been reported in the last few years. Whether or not a deficiency of vitamin D in the nutrition of mature dairy cows will result in the development of any or all of the deficiency symptoms exhibited by calves under similar conditions has remained as an unanswered question. The possibility of vitamin D improving the utilization of calcium and phosphorus by mature cows so that positive balances of these minerals might be maintained during periods of liberal milk production has been studied by workers at the Wisconsin Station (6, 7, 8, 9, 10, 11, 12, 13). In this series of experiments, green roughages, roughages dried with varying amounts of sunshine exposure, sunlight, ultra-violet light, cod liver oil, and irradiated yeast were studied for their influence on calcium and phosphorus metabolism. They were used either as a part of the ration or supplemental to normal rations carrying different amounts of calcium and phosphorus. Under these conditions the authors were unable to demonstrate any consistent significant influence of vitamin D in improving the utilization of these minerals. Meigs and coworkers (14) also concluded from their work that the addition of cod liver oil to the ration had no favorable influence on calcium assimilation.

The present investigation was designed to study the necessity of vitamin D in the adequate nutrition of mature dairy cows by first depriving them of this factor, watching for the development of any symptoms which might result from a vitamin D deficiency, and then attempting by the administration of vitamin D to relieve or improve such conditions as might develop.

EXPERIMENTAL METHODS

The essential features of this experiment included the keeping of mature dairy cows under conditions as free from food and environmental sources of vitamin D as possible and making such observations as might reveal the development of any abnormalities commonly associated with a deficiency of this factor.

Five mature, grade Holstein cows have been used so far in this experiment. Three heavy milking cows of this group have supplied most of the data reported in this paper. The cows were kept inside except for occasional exercise periods in a dry lot after dark. Weights were obtained on three

consecutive days once per month. The rations were designed to be adequate except for vitamin D. To accomplish this it was necessary to use molasses beet pulp as the source of roughage as most of the common roughages carry more or less vitamin D. Samples of the beet pulp used were tested biologically in our laboratory and were shown to be free of detectable amounts of vitamin D. A grain mixture of ground yellow corn, ground oats, and corn gluten meal was used to balance the ration. The grain mixture also included common salt and sufficient bone meal to supply what would normally be an adequate amount of calcium and phosphorus. The mineral allowance provided at least 20–25 grams of calcium and 10 grams of phosphorus for maintenance of the cow and in addition 1 gram of calcium and 0.75 gram of phosphorus for each pound of milk produced daily. Additional vitamin A was supplied by a special concentrate which was shown by biological assay to contain no significant amount of vitamin D. The mangers were partitioned off so that each cow could be fed individually and refused feed accounted for on the feed record. Shavings were used for bedding.

Three-day composite blood plasma samples were obtained regularly at monthly intervals for the determination of total calcium and inorganic phosphorus. Additional samples were taken at irregular intervals whenever the condition of the animal indicated that pertinent data might be secured. Calcium was determined by adaptations from the method of Clark and Collip (2) and phosphorus by the Fiske-Subbarow method (4).

Calcium and phosphorus balances were determined in ten-day trials at about monthly intervals and more frequently when made necessary by the condition of the animal. The balance trial rations were fed for several days previous to the start of collection periods. They were weighed out in daily portions and sampled for analysis in advance of the trial. The cows were placed in adjustable metabolism stalls on elevated platforms so that a large pan with removable shield could be placed at the rear to collect the excreta which were aliquotted at regular intervals and composited at the end of the trial. The feed stuffs and excreta were analyzed by methods essentially the same as those described by Morris, Nelson, and Palmer (15).

Butter fat samples for vitamin D assay were obtained by saving all the milk from the cows concerned for a sufficient period of time to give a two-quart jar of pure butter oil after it had been separated, churned, and either filtered or centrifuged to remove the curd. It was stored at about 0° F. until assayed for vitamin D using the standard line-test technique.

Calcium and phosphorus analyses were run on milk samples taken from the colostrum, from a one-day composite at the end of the third day, and from two-day aliquots taken at the fifteenth day, thirtieth day, and at subsequent thirty-day intervals throughout the lactation.

The physical condition of the cows was observed at regular intervals and notations made of any conditions which would be of value in interpreting the

results of the experiment. The customary breeding, health, and milk records were also obtained.

RESULTS

In a study of this type the conditions and responses pertaining to each individual animal necessarily show some variations. To make the presentation as intelligible as possible the full set of observations and data for each cow will be given separately in this section. The implications of the data as a whole, and generalizations deduced therefrom will be presented later in the discussion section.

Cow 3E.—The animal designated as 3E was placed on the vitamin D deficient ration on Dec. 15, 1935. She completed a lactation in March and freshened normally on April 12, 1936. As shown in Chart 1, the total calcium of the blood plasma had been in the normal range of 10–12 milligrams per 100 cc. and the inorganic phosphorus in its normal range of about 5 milligrams per 100 cc. previous to the approach of parturition. No abnormalities were in evidence until two days after giving birth to a robust, 108 pound male calf when the cow seemed to be paralyzed in her back and limbs. She was unable to get up further than onto her knees but could then drag herself around the boxstall to a limited extent. The blood calcium at this time had declined to 5.3 mgm. per 100 cc. of plasma and the inorganic phosphorus to 3.1 mgm. Five hundred cc. of cod liver oil were administered over a two-day period in an attempt to improve her condition. The cow was on her feet the following day and in a few days was eating her feed readily. The rapid increase in the blood calcium and phosphorus is indicated on Chart 1. Milk production increased until she was giving about 62 pounds daily. A recession in the level of blood calcium and phosphorus soon set in again, and about four months after freshening evidences of stiffness began to appear. There was some swelling of the joints and the knees began to spring forward. She walked with the stiffness exhibited by calves suffering from a vitamin D deficiency, and scarcely flexed the joints of her legs. Her backbone became so stiff that she could not bend it to lick herself, neither did she flex it in walking or turning around. She had great difficulty in lying down and getting up and when standing she frequently lifted each foot with a trembling motion evidently to ease the pain by removing the weight from it.

A ten-day balance trial was run, and a sample of butterfat was saved for vitamin D assay just before these conditions became so severe that remedial measures had to be taken. As shown in Table 1, the calcium balance was negative by 24.06 grams and the phosphorus only slightly positive to the extent of 6.97 grams for the ten-day trial. There was no detectable amount of vitamin D in the butterfat sample as was indicated by the fact that five rats from different litters completed the assay requirements satisfactorily,

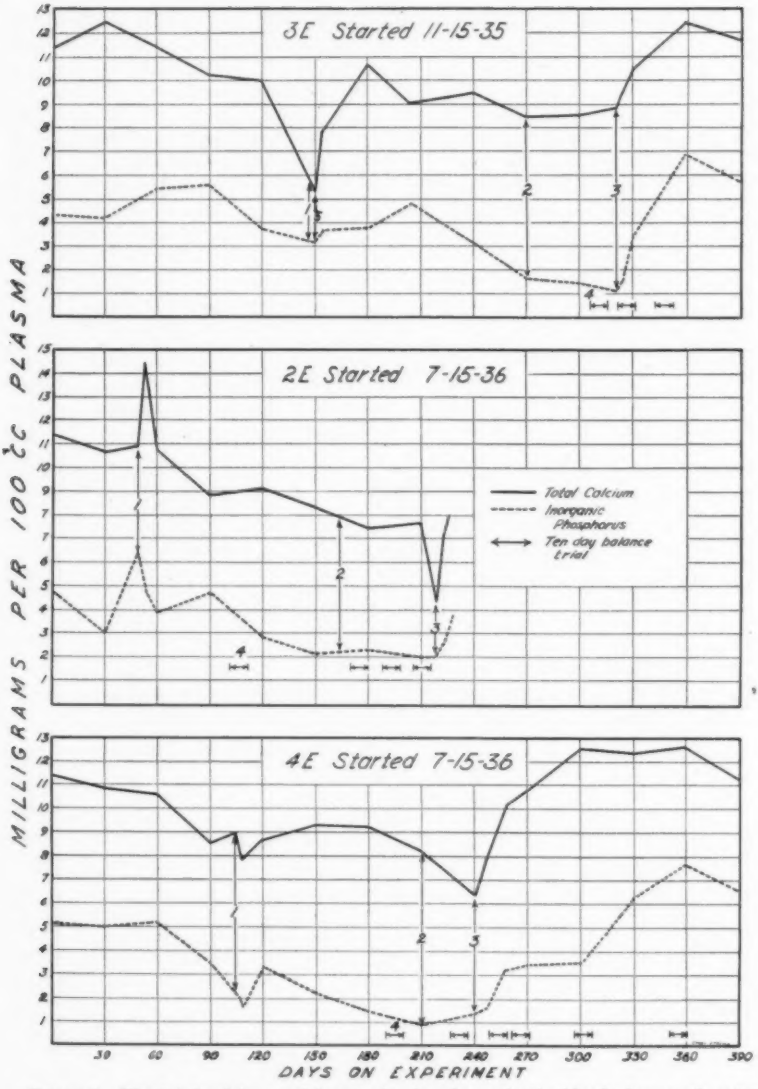
3E Started 11-15-35
2E Started 7-15-36
4E Started 7-15-36
Total Calcium
Inorganic Phosphorus
Ten day balance trial
MILLIGRAMS PER 100 CC PLASMA
DAYS ON EXPERIMENT
30 60 90 120 150 180 210 240 270 300 330 360 390

CHART 1. The total calcium and inorganic phosphorus in the blood plasma of mature dairy cows on a vitamin D deficient ration.

1—Time of parturition.
2—First appearance of stiffness.
3—Viosterol administration started.
4—Spacing of ten-day mineral balance trials. Results given in Table 1.
5—500 cc. cod liver oil given 3E in a two-day period.

TABLE 1

The results of ten-day calcium and phosphorus balance trials run on vitamin D deficient cows before and after the administration of vitamin D

Date trial started	Daily milk yield	Ten-day intake		Ten-day balance			
				Before feeding vitamin D		After feeding vitamin D	
		Calcium	Phosphorus	Calcium	Phosphorus	Calcium	Phosphorus
	lbs.	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*	*gm.*
			3E 4–12–36 calving				
9–22–36	22.7	480.29	363.41	(−) 24.06	(+) 6.94		
10– 6–36	18.7	390.70	262.20			(+) 65.10	(+) 39.72
10–27–36	14.3	387.44	227.74			(+) 230.20	(+) 108.01
11–24–36	13.8	413.89	261.07			(+) 204.93	(+) 106.78
			2E 9–4–36 calving				
10–27–36	32.9	568.69	393.13	(−) 138.40	(−) 74.94		
1– 5–37	20.1	392.56	269.67	(−) 89.27	(−) 21.63		
1–20–37	16.0	295.01	169.25	(−) 81.06	(−) 54.94		
2– 9–37	13.0	323.91	182.95	(−) 55.96	(−) 24.57		
			4E 11–2–36 calving				
1–26–37	24.9	430.10	283.60	(−) 107.18	(−) 36.49		
3– 2–37	19.8	507.50	277.20	(−) 38.13	(+) 1.67		
3–23–37	18.9	561.31	296.78			(+) 131.78	(+) 48.49
4– 6–37	19.5	476.00	296.00			(+) 239.51	(+) 102.99
5–11–37	20.2	496.63	244.91			(+) 213.99	(+) 94.68
7– 6–37	22.5	576.19	343.57			(+) 185.38	(+) 101.16
Algebraic Totals				(−) 534.06	(−) 203.96	(+) 1270.89	(+) 601.83

but none of them showed any healing from the twelve grams of fat given each one during the test period.

Five and one-half months after parturition the blood calcium was down to 8.5 mgm. and the phosphorus to 1.1 mgm. per 100 cc., and her distress became so severe that 5 cc. of viosterol were given daily to supply vitamin D. Another mineral balance trial was started on the same day that viosterol therapy was initiated. A third balance trial was started ten days after the close of the second trial. The large calcium and phosphorus retentions which now prevailed as contrasted to the negative balance of calcium and slight positive balance of phosphorus under vitamin D deficient conditions are shown in Table 1. A fourth trial run two weeks later indicated the continued retention of large amounts of calcium and phosphorus. Three weeks after viosterol feeding was started the blood plasma calcium and inorganic phosphorus were back to the normal range again and the physical condition had improved to such an extent that only a slight stiffness could be discerned as she walked.

The calcium and phosphorus in the milk under the conditions of this lactation as compared with the amounts found in a previous normal lactation are shown graphically in Charts 2 and 3. The smoothness and similarity of

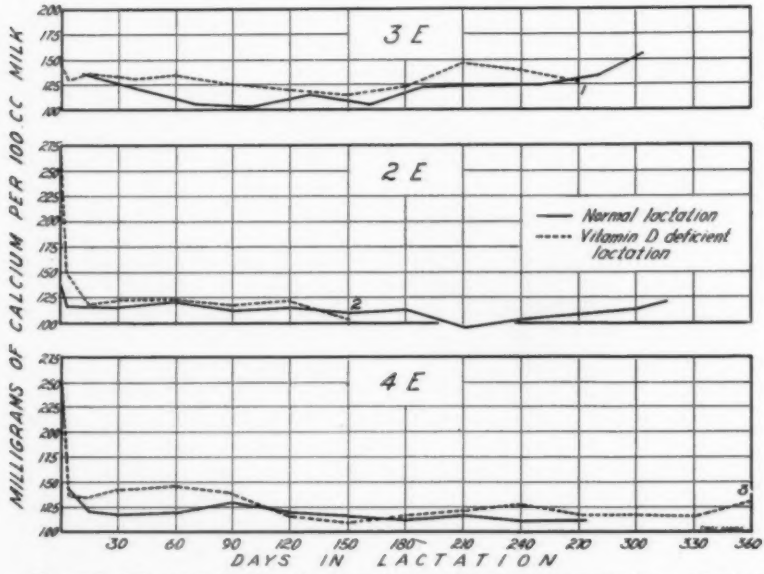

CHART 2. The concentration of calcium in the milk of three cows during a vitamin D deficient lactation as compared with a previous normal lactation.

1—Incomplete lactation—3E sold.
2—Cow 2E died.
3—Lactation still not completed. Delayed pregnancy due to failure of estrum during vitamin D deficiency allowed for extended lactation period.

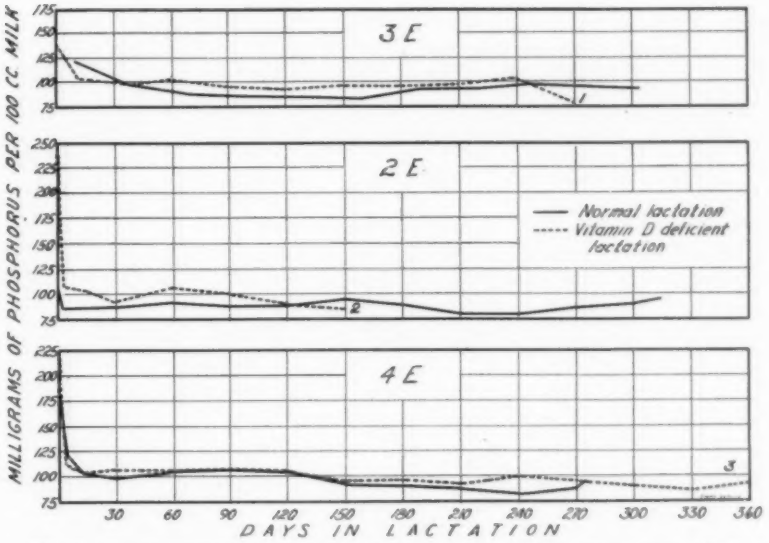

CHART 3. The concentration of phosphorus in the milk of three cows during a vitamin D deficient lactation as compared with a previous normal lactation.

1—Incomplete lactation—3E sold.
2—Cow 2E died.
3—Lactation still not completed. Delayed pregnancy due to failure of estrum during vitamin D deficiency allowed for extended lactation period.

the two curves in each case gives no indication that the level of calcium and phosphorus in the milk was affected significantly by the deficiency of vitamin D. A study of the percentage of calcium and phosphorus in the milk obtained in balance trials run before and after vitamin D therapy also substantiates this view. In the balance trials run under vitamin D deficient conditions the concentration of calcium in the milk was 0.1112 per cent and of phosphorus 0.0964 per cent, while in the two trials run immediately after feeding the vitamin D the calcium percentages were 0.1162 and 0.1091 respectively, and the phosphorus 0.0947 and 0.0876, respectively. Although the composition of the milk was not changed with regard to its calcium and phosphorus content, there was, however, a pronounced decline in the quantity produced, the drop from the high level of production in early lactation being much more rapid than for a comparable normal lactation.

Cow 3E was never observed to show estrum during the vitamin D deficient lactation although her breeding record previous to this time was very commendable. She was reported suspicious to the abortion test and was sold while still in milk nine months after calving.

Cow 2E.—This animal was transferred from a normal ration to the vitamin D deficient ration during the first week of July, 1936. After eight

weeks on this ration she gave birth to a strong, 101 pound male calf on Sept. 4. No abnormalities were in evidence although the blood plasma calcium and inorganic phosphorus had been declining previous to parturition and fluctuated conspicuously during the calving interval as is indicated in Chart 1. She was soon eating well and giving up to 42 pounds of milk daily. The blood plasma calcium and inorganic phosphorus continued to decline and on Oct. 27, about seven weeks after freshening the first mineral balance trial was run. There was no evidence of stiffness at this time. The large negative balances of both calcium and phosphorus are shown in Table 1. By the last of December, 15 weeks after freshening, stiffness was developing, the knees were swelling, and the back was elevated and held rigid as she moved about with a stiff, shuffling gait. Three more balance trials were run in rapid succession as shown in Table 1. During this time her physical condition became gradually worse so that by the end of the fourth trial she needed assistance to get to her feet although she was still in fair flesh. Her appetite was not keen and during the last two trials the mineral intake fell slightly below the desired intake to meet the calculated requirements for maintenance and milk production. Negative balances of calcium and phosphorus prevailed in all of these balance trials.

During the time that the vitamin D deficiency symptoms were pronounced a butterfat sample was saved for assay, but it was impossible to detect any vitamin D as indicated by the fact that the seven rats receiving 12 grams of this fat showed no signs of healing except for a mere trace on one animal. A photograph was also taken to show how her knees were buckled forward. This picture is shown in Figure 1. On February 23, about 23 weeks after freshening, and following the completion of the fourth balance trial, an attempt was made to secure a few more feet of moving pictures to supplement those previously taken to show the movements characteristic of this deficiency, but the animal was unable to get up even with the help of three or four men. She showed some tetany after slight exertions. A blood sample was taken in which the calcium was found to be only 4.35 mgm. and the inorganic phosphorus 2.00 mgm. per 100 cc. of plasma. Five cc. of viosterol were given in a drench and this was continued twice daily for the next five days. The rapid improvement in the blood plasma calcium and inorganic phosphorus is indicated in Chart 1. Although she was unable to get up, she continued to look bright and alert, and to eat some for three or four days. Gradually, however, her eyes dulled, her ears began to droop, and she became more and more listless until she died on March 1, six days after she was first unable to get up.

The Veterinary Department assisted with a post mortem examination in which it was found that both femur bones had been broken. Large hemorrhagic areas were present throughout the region of the hip and thigh muscles. Some fiber formation had taken place and the muscle tissues were decomposing, indicating that the bones had been broken for several days. This

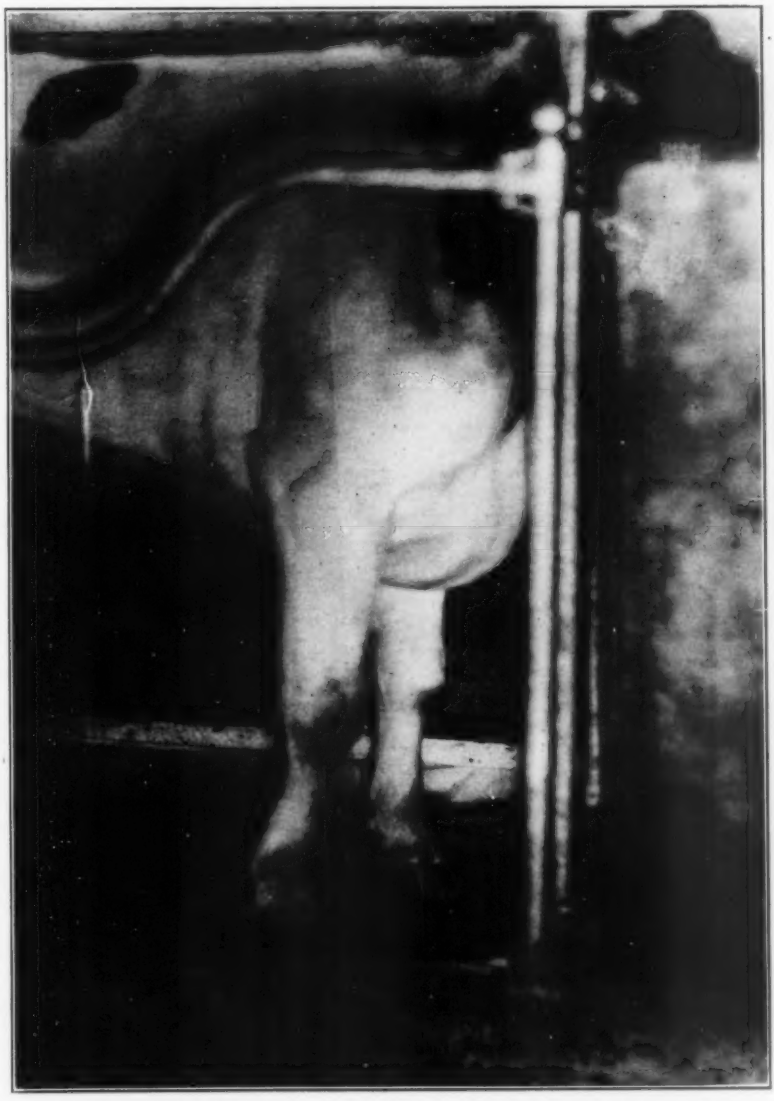

FIG. 1. A vitamin D deficient cow, 2E, showing the knees bent forward.

observation also harmonizes with observations made in the barn notes by the man attending the animal. The broken end of one femur had punctured the abdominal wall. It was quite evident that generalized septicemia had been the immediate cause of her death. The bones must have been uncommonly brittle as likely they were broken sometime when the cow was attempting to get up. She was never seen to struggle violently at any time. One can only conjecture as to whether or not the vitamin D deficiency played any part in making the bones fragile but it would seem quite possible that it may have contributed to this condition. A picture of these bones is shown in Figure 2.

FIG. 2. Broken femur bones from a vitamin D deficient cow, 2E.

The articulating surfaces of the joints seemed to be smooth and normal except for an eroded area about ¾ inch in diameter on the proximal end of the right humerus. The ovaries seemed normal, but one of them contained a corpus

luteum which may account for the fact that this animal never showed estrum during this lactation although per previous breeding record was entirely regular.

The data shown in Charts 2 and 3 indicate that the amounts of calcium and phosphorus in the milk produced under the severe vitamin D deficiency conditions of this lactation were not essentially different from the amounts contained in the milk of a previous normal lactation. As it was not possible to run a balance trial after vitamin D administration, a comparison of the calcium and phosphorus concentration in the milk before and after such a change in the schedule is not possible in this case.

Cow 4E.—This animal was also started on the vitamin D deficient ration early in July of 1936. Chart 1 shows that there was a steady downward trend in the blood plasma calcium and inorganic phosphorus which was accentuated the last six weeks before parturition which occurred on November 4, 1936. The 90 pound heifer calf seemed well developed, bright, and alert, but its legs were badly crooked, giving it an outward appearance of a rachitic condition as may be seen in Figure 3. The calf could stand and move around

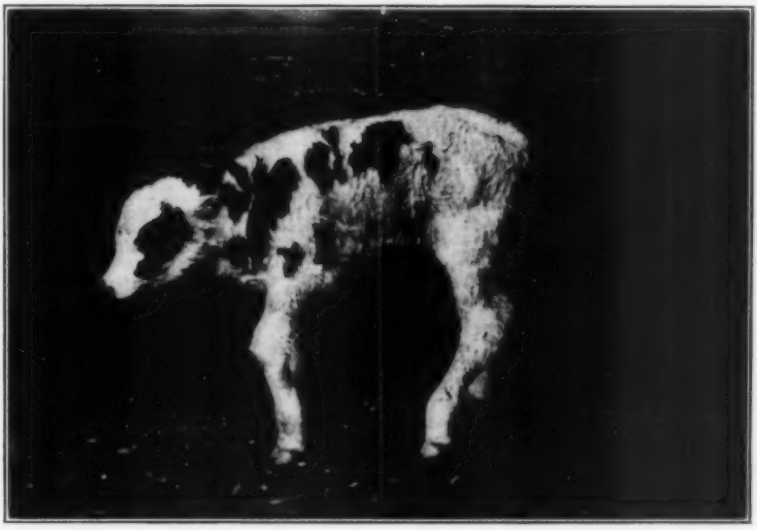

FIG. 3. Calf born to cow 4E after about four months on the vitamin D deficient ration.

but its body was only about two-thirds as far from the ground as it should have been. A blood sample from the calf showed the calcium to be 11.46 mgm. and the inorganic phosphorus 7.10 mgm. per 100 cc. of plasma. In four days the legs of the calf had straightened considerably. The cow did not show any external symptoms of deficiency disturbances.

There was a partial recovery in the blood plasma calcium and inorganic phosphorus following the low points and fluctuations associated with the calving period, but in about six weeks the downward trend again prevailed. The milk flow was maintained at about 40 pounds daily during the flush of the lactation. The first mineral balance trial was started on January 26, 1937, eleven weeks after calving. The blood calcium and phosphorus were subnormal but stiffness had not developed. The negative balances shown in Table 1 for this trial indicate large drafts on the calcium and phosphorus reserves of the cow.

By the last of February, 15 weeks after parturition, stiffness was quite noticeable, and the animal was in a thin condition from being off-feed. The desired level of mineral intake was maintained, however, by increasing the allowance of bone meal supplement. By the time a second balance trial was completed the animal was very stiff and could scarcely get up and down, or move around. No vitamin D could be demonstrated in a sample of butterfat saved for assay at this time. The blood plasma calcium was down to 6.46 mgm. and the inorganic phosphorus to 1.34 mgm. per 100 cc. in the three-day sample taken just before viosterol feeding had to be started on March 16, about 18 weeks after parturition. Five cc. of viosterol were given daily. In four days she was eating better, and in seven days when the next balance trial was started her appetite was still better, her eyes brighter, and her ability to move about much improved although she was still noticeably stiff. According to the results of this trial as shown in Table 1, the negative balances had changed to strongly positive balances. In the fourth trial which followed immediately, the retention of calcium and phosphorus increased by another large increment. In the fifth and sixth trials coming at later intervals the large mineral retentions were well sustained. In all six of these trials the milk production remained quite constant and the mineral intake was fairly uniform at adequate normal levels. Five weeks after starting viosterol feeding the stiffness seemed to have disappeared and her appetite had improved so that she was fleshing up from the excess nutrients consumed. About the middle of June cod liver oil was substituted for the vitamin A concentrate and viosterol to supply vitamins A and D. On July 16, 1937, she showed estrum for the first time since calving on November 4, 1936. She had now recovered and was seemingly in a fair state of health.

The calcium and phosphorus content of the milk during this lactation is compared with similar data for a previous normal lactation in Charts 2 and 3. Again, the curves are quite remarkable for their similarity. Furthermore, the analysis of the milk from balance trials run before and after viosterol feeding show no consistent differences to indicate a decrease in the calcium and phosphorus content of milk produced under conditions of severe vitamin D deficiency. In the two trials before feeding vitamin D the calcium in the milk was 0.1266 per cent and 0.1126 per cent and the phosphorus 0.0995 per

cent and 0.0958 per cent respectively, while in the two trials run immediately after vitamin D administration the calcium was 0.1088 per cent and 0.1123 per cent and the phosphorus 0.0984 per cent and 0.0954 per cent respectively.

Cow 1E.—A few observations made on this animal will be presented chiefly as they concern the effects of a vitamin D deficiency on the developing fetus. This cow was on the vitamin D deficient ration and was also dry at the time she became pregnant. She was continued under these conditions throughout the gestation period. The blood plasma calcium and inorganic phosphorus remained normal until about six weeks or two months before parturition when a downward trend developed. A low of 8.50 mgm. of calcium and 3.08 mgm. of inorganic phosphorus per 100 cc. of plasma was reached. There were fluctuations at calving time followed by a temporary recovery, then a decline as the lactation proceeded.

Some idea of the condition of the calf may be obtained from the picture shown in Figure 4. The legs were really less useful than the picture would indicate as they would bend and twist into most any shape if the calf tried to move about. The calcium in the blood plasma of the calf was 11.44 mgm. and the inorganic phosphorus 5.81 mgm. per 100 cc. The calf seemed to im-

FIG. 4. Calf from cow 1E. This cow was dry and on the vitamin D deficient ration throughout the entire gestation period.

prove slightly for 3 or 4 days then appeared to grow weaker again. It developed a light case of scours and died on the seventh day. It was fed only the milk from its vitamin D deficient mother. There was a feeling that the calf would have stood a good chance to live had it received some cod liver oil or other source of vitamin D, and possibly some vitamin A. The costochondral junctions of the ribs seemed to be enlarged so a histological study was made on the seventh rib by Dr. J. B. Taylor of the Veterinary Department. The structure was found to be essentially normal with regular columns of cartilage cells and a smooth line at the junction between the cartilage and calcified area. The ribs seemed light in weight and had only a very thin shell of mineral deposit. A little pressure caused the left sixth rib to crease and bend as a hollow straw. Analysis showed that on the green weight basis this bone contained 66.06 per cent moisture, 14.28 per cent ash, and 0.34 per cent fat (this determination may be a little low), leaving 19.32 per cent for other organic materials. The ash contained 38.24 per cent of calcium and 19.75 per cent of phosphorus.

DISCUSSION

In this section the data and observations just presented for individual animals will be analyzed for the broader implications and generalizations which may be drawn to suggest expected or possible effects of a vitamin D deficiency on mature dairy cows.

Total Calcium and Inorganic Phosphorus of the Blood Plasma

By referring to Chart 1 it may be noted that a gradual decline in the total calcium and the inorganic phosphorus content of the blood plasma set in soon after the cows were placed under vitamin D deficient conditions. Six weeks or so before calving the rate of decline was accelerated presumably because of increased demands on the mother made by the rapidly developing fetus. At calving time there were fluctuations up and down but usually all at subnormal levels. Following the stress of the parturition period there may be a partial recovery to normal concentrations but the requirements for a liberal milk flow initiated a downward trend again in two or three months. In about six months the level of calcium had reached a low of from 5–7 mgm. per 100 cc. of plasma in some cases, and the inorganic phosphorus had declined to 1–2 mgm. Upon the administration of viosterol to supply vitamin D recovery was rapid so that in about two or three weeks the concentrations were well back toward, or within, the normal range.

These observations were made on cows due to freshen within a few months of the time the experiment was started, and they were also liberal milk producers. Whether or not non-pregnant, dry cows and poor producing animals will respond similarly are unanswerable questions which are under investigation at the present time.

The Physical Condition of the Animal

With the exception of the peculiar paralysis of 3E at the time of parturition, these three heavy-milking cows all began to develop stiffness under vitamin D deficiency conditions about three or four months after the beginning of the lactation. It usually developed shortly after the decline in blood plasma calcium and phosphorus had been definitely established. From a slight stiffness the condition grew gradually more severe. The knees bent forward, the ankles straightened throwing the weight forward onto the toes, the joints showed some swelling, the back became slightly arched and quite rigid so that it was not flexed in walking, turning, or in other body movements. The gait was stiff, slow, and shuffling, when the animal was forced to move. The appetite usually failed some, and in two or three months the condition was often so severe that assistance was necessary in getting the animal to its feet. After viosterol administration to supply vitamin D some improvement in the appetite and ease of body movements could usually be noted in about ten days. Gradual improvement continued so that within one or two months the animal was apparently normal again as far as could be seen from external observations. Whether these conditions would develop with cows milking less liberally or with dry cows are questions under investigation at the present time.

The Calcium and Phosphorus Balances

The results of ten-day mineral balance trials distributed at advantageous points over the period of observation on these cows are summarized in Table 1. The trials run while the vitamin D deficiency was developing show negative balances for calcium in all cases and for phosphorus in all but two cases for which approximate equilibrium is indicated. When the mineral feeding was continued at a level adequate for maintenance and the amount of milk produced, these negative balances were all changed to strong positive balances upon the administration of viosterol to supply vitamin D. The data for 4E are especially pertinent for in this case the milk production remained practically constant for six different trials and the mineral intake quite uniform and never fell to questionable levels at any time through loss of appetite or other causes. The two trials run under vitamin D deficient conditions show significant losses of minerals from the body. Immediately upon administration of vitamin D these losses were converted into large retentions amounting to nearly one-half pound of calcium and one-fourth pound of phosphorus in a ten-day period. It is recognized that heavy-milking cows in the flush of the lactation often show negative calcium and phosphorus balances for a short time but positive balances have usually been reestablished before the milk production has declined to the levels indicated in these trials. That vitamin D plays an important role in the ability of heavy-milking cows to utilize calcium and phosphorus is indicated by the unusual losses of these min-

erals under vitamin D deficient conditions and the abrupt change to large retentions upon the administration of viosterol. It may be noted from the total figures at the bottom of Table 1, that the losses from the body during vitamin D deficiency and the subsequent gains following viosterol administration were both in approximately a 2 to 1 ratio and suggest a depletion followed by a subsequent restoration of the mineral reserves of the skeleton.

On first thought it might appear that these results are at variance with those previously referred to from the Wisconsin Station but the explanation undoubtedly lies in the two different approaches used. In the Wisconsin experiment vitamin D supplements were added to normal rations which undoubtedly carried enough of this factor to meet normal requirements so that no measurable effects on the calcium and phosphorus balances or condition of the animals were produced by adding still larger quantities of vitamin D. In the present work, the animals were first deprived of vitamin D whereupon deficiency symptoms developed thus providing favorable conditions for fundamental studies on the relation of vitamin D to the utilization of calcium and phosphorus as shown by balance trials, blood chemistry, and other conditions.

It is interesting to note that the effects of a vitamin D deficiency on the blood chemistry, physical condition, and calcium and phosphorus balances of mature heavy-milking cows as just related are very similar to those exhibited by young growing calves as reported by Bechdel, Landsburg, and Hill (1), Rupel, Bohstedt, and Hart (16), Duncan and Huffman (3), Gullickson, Palmer, and Boyd (5), and Wallis, Palmer, and Gullickson (18).

Calcium and Phosphorus in the Milk

The data obtained from analyzing two-day composite samples of milk from each cow at monthly intervals for calcium and phosphorus are shown graphically in Charts 2 and 3. In comparing them with results obtained in a previous normal lactation the similarity of the curves is the most striking feature. There is even a slight tendency for both the calcium and phosphorus concentration to be higher in the vitamin D deficient lactation. These curves are remarkably smooth, follow the normal curves closely, and show no tendencies to decline under these extreme conditions of vitamin D deficiency nor to rise upon the administration of vitamin D. There was, however, a more rapid fall in the amount of milk produced as the vitamin D deficiency became pronounced than was shown in normal lactations. It should be noted that none of the lactations of the vitamin D deficient period were entirely completed so the last part of these curves is not necessarily characteristic of completed lactation curves.

The data for the percentage of calcium and phosphorus in the milk from balance trials run before and after vitamin D therapy also support the same

conclusion; namely, that the vitamin D deficiency had no measurable influence on the concentration of calcium and phosphorus in the milk.

Vitamin D in Butterfat

The data obtained in the assays indicate that in none of these samples of fat taken from the cows while suffering severely from a deficiency of vitamin D was it possible to demonstrate the presence of measurable amounts of vitamin D. Twelve grams of fat were mixed with the rachitogenic diet and fed during the first eight days of the test period. This is about all the rats would consume regularly during the test period so larger amounts could not be used. Unsuccessful attempts to concentrate any possible vitamin D in the butterfat so a more searching test could be made have been discussed by the author (17) on a previous occasion.

Effects on the Developing Fetus

Cow 2E dropped a fine normal-appearing calf after two months of the dry period under the vitamin D deficient conditions. The calf from 3E born four months after starting the experiment, showed slightly bent knees and cocked-ankles, but straightened up in a week or so. The calf from 4E, born after four months on the deficient diet, is shown in Figure 3. The legs are extremely crooked, but the blood plasma calcium and inorganic phosphorus were normal. The legs gradually straightened over a period of two or three weeks. The calf from 1E is shown in Figure 4. This cow was dry and on the vitamin D deficient regime throughout the gestation period. The blood picture was essentially normal, and the histological studies made on the costochondral junction of the seventh rib after its death on the seventh day showed no evidences of rachitic malformations. The high moisture content and the low fat and ash contents indicated by the analyses of the sixth rib are interesting but at the present time we do not have figures from comparable normal calves with which to compare them. The calcium and phosphorus found in the ash approximate the figures generally reported for bone ash. The evidence indicates that calves born to cows maintained for a considerable length of time under vitamin D deficient conditions may have a decided rachitic appearance and possibly a lowered mineral content of the bones. Blood chemistry and histological studies, however, have shown normal conditions to prevail in these respects.

Bones of the Animal

In connection with 2E the evidence has already been presented which may possibly indicate that the vitamin D deficiency has had some relation to the marked fragility of the bones encountered in this case.

Breeding Efficiency

The breeding records are available for these animals for at least two lactations previous to the experiment. The regularity shown by these records stands out in striking contrast to the fact that none of these cows showed estrum during the period of vitamin D deficiency. It is not clear, however, whether this condition should be attributed to the lack of vitamin D *per se*, to the decline in general health and vigor of the animals, or perhaps to some other factor entirely.

SUMMARY

Detailed observations on three liberal-milking cows and one dry, pregnant cow kept under vitamin D deficient conditions have been presented. Under these conditions the total calcium of the blood plasma declined to one-half normal values, and the inorganic phosphorus to one-fifth normal. The animals became stiff, the knees bent forward, the spine became rigid and in severe cases assistance was necessary before the cow could get up. Balance trials run while these conditions prevailed showed that significant drafts on the calcium and phosphorus reserves were being made. When vitamin D was administered the losses were immediately changed to unusually large retentions. The curves showing the calcium and phosphorus concentration in the milk are remarkably smooth and coincide closely with similar curves for previous normal lactations. Calves produced after the cows had been under the deficiency conditions for some time showed visible rachitic appearances but blood chemistry and histological studies revealed no abnormalties in these respects. Vitamin D could not be detected in butterfat samples saved from animals deficient in this factor. Whether or not the fragile bones encountered in one animal and the failure of all the animals to show estrum are directly connected with the lack of vitamin D cannot be established at the present time.

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SPECIAL PUBLICATIONS

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International Association of Milk Dealers

National Institute for Research in Dairying, Reading, England
New York Association of Dairy and Milk Inspectors

Prussian Dairy Research Institute, Kiel, Germany

State Agricultural Colleges and Experiment Stations

The Royal Technical College, Copenhagen, Denmark

United States Department of Agriculture

ABSTRACTS OF LITERATURE

BACTERIOLOGY

225. Bactericidal Property of Milk. RALPH B. LITTLE, Rockefeller Institute, Princeton, N. J. 25th Ann. Report of Intern. Assoc. Milk Sanitarians, p. 105, 1936.

All milks studied had a substance present which inhibited the growth of non-hemolytic mastitis streptococci and known cultural strains of scarlet fever streptococci. This inhibitory effect was noticeable for several hours. The concentration of the inhibitory principle varies in the secretions of different animals and frequently in the quarters of the same animal.

It is assumed that the substance is produced in the udder of the animal and that its function is primarily a natural means of restraining the growth of bacteria in the udder.

Whether or not this substance is potent for many kinds of bacteria is not known. However, we must realize the opportunity available for the entrance of bacteria into the teat canal, yet, in the main, the flora of the udder is limited to relatively few species; and these species have probably become well adapted to the environment and to the influence of this inhibitory substance. L.HB.

BUTTER

226. Regulatory Problems Relating to the Manufacture of Butter. CHARLES S. TRIMBLE, U. S. Bureau of Dairy Industry, Washington, D. C. 25th Ann. Report of the Intern. Assoc. Milk Sanitarians, p. 311, 1936.

A discussion of some of the phases of butter manufacturing which require supervision by regulatory agencies. L.H.B.

227. The Cold Storage of Butter. F. BROCHOT, Le Lait *18*, 171, p. 23, Jan., 1938.

Refrigeration equipment in cold storage chambers for butter is discussed. The importance of maintaining a low humidity in the butter storage chamber is emphasized. In putting butter into storage for long periods, the work indicates that the butter be prepared from cream pasteurized at a high temperature and manufactured carefully and not permitting contact with copper. The butter storage chamber should be free from mold and should be washed with chlorine solution before storage of the butter. Light should be excluded from the butter storage chamber. Condensed water from cold surfaces in the cold storage chamber should be eliminated as far as possible. A.H.J.

228. The Diacetyl in the Butters of Normandy. CH. BRIOUX AND EDG. JOUIS. Agronomic Sta. of the Lower Seine. Le Lait *18*, 171, p. 11, Jan. 1938.

The diacetyl and acetyl methyl carbinol contents of a considerable number of butters were determined by the method of Pien. Determination of acetyl methyl carbinol was accomplished by introducing 100 grams of the butter into a 300 to 400 cc. flask, adding 20 cc. of iron perchloride and distilling slowly with steam until 50 cc. of distillate were obtained. Ten cc. of the distillate were then used in the colorimetric determination of the contained diacetyl according to the method of Pien. Fresh Norman butters contained normally a small quantity of diacetyl, usually from 0.05 to 0.5 milligrams of diacetyl per kilogram and in rare cases as much as 2.5 milligrams of diacetyl per kilogram of butter were found. Butters made in cooperative or industrial creameries contained considerably more diacetyl than butter made on the farm. The diacetyl normally contained in fresh butter disappeared rapidly on storage of the butter. Fifteen to 18 days after manufacture of the butter, the diacetyl content decreased to $\frac{1}{10}$ its original value. The acetyl methyl carbinol contents of butter are considerably higher than the diacetyl contents, usually between 10 and 30 milligrams per kilogram of butter, but some butters may contain as high as 69 milligrams per kilogram. The acetyl methyl carbinol did not appear able to give rise to an appreciable quantity of diacetyl. The diacetyl and acetyl methyl carbinol contents of fermented cream containing 95.2 milligrams of acetyl methyl carbinol per kilogram yielded butter and buttermilk containing 42.4 and 195.3 milligrams of acetyl methyl carbinol per kilogram respectively. The same cream containing 1.92 milligrams of diacetyl per kilogram yielded butter and buttermilk containing 1.50 and 3.10 milligrams of diacetly per kilogram respectively.

A.H.J.

Other abstracts of interest are numbers 246, 251, and 254.

CHEESE

229. Cheese Vats of Non-oxidizable (Stainless) Steel. JOSEF KRENN, School and Federal Exp. Sta. for the Dairy Industry, Wolfpassing, Austria. Le Lait *18*, 171, p. 1, Jan., 1938.

It was noted that when curd was prepared in non-oxidizable steel vats, the curd adhered to the walls of the vat and formed a spongy coagulum while when copper vats were used the curd drew away from the wall and formed a more desirable hard curd free from whey. It was not that this phenomenon was due to the probability that in the case of copper containers, minute traces of the copper walls dissolved allowing thereby the curd to draw from the walls. This explanation was found to be incorrect. It made no difference whether raw milk, pasteurized milk or skimmilk used in the vats, the curd in all cases adhered to the stainless steel or nickel chromium vat, while it drew away from the copper vat. Modifying the acidity of the milk, or the temperature or the

amount of rennet had no effect. The curd adhered to glass containers but not to glazed porcelain. The state or condition of the surface of the inoxidizable steel (degree of polishing) was without affect on the adherence of the curd to the surface. It appears to be a particular property of the inoxidizable steel surface that curd presents a particularly high attraction for it. In order to suppress this attraction, it is sufficient to grease carefully the inoxidizable steel vat with butyrin. The cheese curd then detaches itself as easily and as freely from this greased surface as from a copper vat. A.H.J.

CHEMISTRY

230. Some Observations on Chlorine and Metals. Fred M. Grant, Bureau of Dairy Industry, U. S. Dept. of Agr., Washington, D. C. 25th Ann. Report of Intern, Assoc. Milk Sanitarians, p. 9, Oct., 1936.

This paper presents the observations made on the corrosive action of a chloromin-T compound and of a calcium hypochlorite and sodium carbonate mixture on seven different metals, tin, black steel, Monel metal, allegheny metal, copper, aluminum and bronze. The solutions used were of a strength of 200 ppm. of available chlorine. Weighed metal strips were used all of such size that an equal surface was presented in each instance.

It was found that bronze and copper were affected most by the chloramin-T and least by the hypochlorite solution. Tin, Monel metal and allegheny metal were practically untouched by the chloramin-T, but Monel metal and tin were mildly effected by the hypochlorite solution. Aluminum, although strongly attacked by hypochlorite, was only mildly effected by chloramin-T. L.H.B.

CONCENTRATED AND DRY MILK; BY-PRODUCTS

231. The Progress of the American Industry with Compounds of Lactic Acid. G. Genin, Paris, France. Le Lait *18*, 171, p. 43, Jan., 1938.

Milk is freed of its fat and much of its protein. The remaining serum is the source of the sugar for fermentation. The appropriate organisms are added to this serum, and in 10 to 24 hours the lactose is converted into lactic acid. In the course of the fermentation, lime is added from time to time. During the fermentation the temperature is held at about 100° F. When the fermentation is complete, the liquid is neutralized with lime and heated to 180° F. to 220° F. On cooling a slime separates out. The liquid containing the calcium lactate is siphoned off and concentrated under vacuo. After cooling calcium lactate separates from the condensed liquid. Purification is effected by washing the crystals in a centrifuge. The crystals are then dissolved and the solution heated to 140–160° F., the solution also having its pH raised to 10–12 by the addition of calcium oxide. After standing 2–3 hours, the last impurities separate as a slime. The supernatant liquid is

drawn off and neutralized with lactic acid. A further purification may be made by the use of decolorizing carbon. The purified solution is finally cooled and the calcium lactate crystals obtained by centrifugation. A modification of this process is also described. Sodium lactate may also be prepared by treating a solution of calcium lactate with sodium sulphate. The precipitate of calcium sulphate is filtered off and the sodium lactate concentrated under vacuo to a syrupy consistency. Lactic acid can also be prepared from calcium lactate by adding sulphuric acid to a solution of calcium lactate. The lactic acid thus obtained has a slight brown color. This color can be removed by treatment with decolorizing carbons or by treatment with potassium ferrocyanide. A.H.J.

232. Concerning the Use of Casein in the Fabrication of Plastic Materials. G. GENIN, Paris, France. Le Lait *18*, 171, p. 45, Jan., 1938.

A review of the development of plastic materials from casein is given with special reference to the often overlooked work of Trillat. A.H.J.

Other abstracts of interest are numbers 251, 252, 253, 256, and 257.

DISEASES

233. The Present Status of Bang's Disease in Man. RICHARD KERN, Univ. of Penn., Philadelphia, Pa. 25th Ann. Report of Intern. Assoc. of Milk Sanitarians, p. 248, 1936.

This paper gives a very complete history of Bang's disease.

Up to 1935, 9,965 cases have been reported. However, it is apparent that not all cases are reported.

As a result of some of the work done by the government during the last few years, it was found that of 3,317,760 cows examined in this country, 381,657 were reactors, an incidence of 11.2 per cent. Nearly 50 per cent of all herds examined have some reactors.

The disease may be contracted by ingestion of infected raw milk or by contact. Pasteurization will take care of the milk infection, but the underlying problem is eradication of the disease in animals; this must be accomplished. L.H.B.

234. Milk-Borne Streptococci Infections. E. L. STEBBINS, H. S. INGRAHAM AND E. A. REED, Div. of Communicable Diseases, State Dept. of Health, Albany, N. Y. Am. J. Pub. Health *27*, 12, p. 1259, 1937.

An analysis was made of 1,529 cases of milk-borne streptococcus infections occurring in 7 epidemics in New York State during 1934–1936. In 6 epidemics, the source of contamination of the milk supply was a cow suffering from an acute mastitis caused by a hemolytic streptococcus of the type usually

associated with human infection (Lancefield Group A) and there was suggestive evidence of a human source of the bovine infection in each instance. The clinical and epidemiological observations are discussed. M.W.Y.

235. Undulant Fever in Milk, and Its Relation to Bang's Disease in Livestock. G. W. ANDERSON, Mass. Dept. of Public Health. Boston, Mass. J. of Milk Tech. *1*, 1, p. 26, Oct. 1937.

The existence of infection through the medium of raw milk must be recognized. The responsibility of the health officer is discussed.

L.H.B.

236. An Outbreak of Septic Sore Throat in Bergen County, (N. J.). W. H. MACDONALD, N. Y. State Dept. of Health. 25th Ann. Report of Intern. Assoc. of Milk Sanitarians, p. 180, 1936.

In a period of 27 years since 1909 the New Jersey State Dept. of Health investigated 58 disease outbreaks traceable to milk. Fifty-seven of them were traced to raw milk, the other one was traced to pasteurized milk wherein the bottles were hand-capped (20 years ago before machine capping was required) by a person with a mild case of typhoid fever.

Not until 1934 was septic sore throat listed among the milkborne epidemics. Since then three such epidemics have occurred with 325 or more cases and 9 deaths. The last outbreak occurred in April and May, 1936 when 175 cases or more had occurred and there were seven deaths. L.H.B.

237. The Present Status of Milkborne Diseases. Report of Committee on Communicable Diseases Affecting Man. J. G. HARDENBERG. 25th Ann. Report of Intern. Assoc. Milk Sanitarians, p. 120, 1936.

There has been no definite trend in recent years in milkborne epidemics (since 1923).

However, in the past five years the number of deaths reported have averaged less than one per epidemic, whereas prior to that the ratio of deaths to epidemic was 1.3 to 1.

In 1935 there was a total of 43 milkborne epidemics reported in the United States and 2 in Canada. With a total of 1846 cases and 21 deaths.

Typhoid fever and spetic sore throat were responsible for 58 per cent of the epidemics, 64 per cent of the cases and all of the deaths.

The majority of the epidemics in the U. S. occurred in small communities; 27 were in towns of less than 5,000 population, 10 in towns of 5,000 to 25,000, four in cities of 25,000 to 50,000 and only two in cities of more than 100,000.

Raw milk as usual was the chief offender.

Pasteurized milk was involved in five cases but in three of them some raw milk was also consumed and in two of them the supplies were improperly pasteurized.

In addition to the cases reported above, there were 1936 cases of undulant

fever reported in the U. S. cause undetermined, however. In Canada there were 124 cases a large percentage of which were traced to milk from herds containing animals having Bang's disease.

Great progress has been made in developing safe wholesome milk supplies. In continuation of this program our efforts should be directed to:

1. Education of the consuming public to the importance of clean and healthful milk in the diet of individuals of all ages.

2. Education of dairymen to their responsibility and importance of their part in producing wholesome milk.

3. Promotion of pasteurization wherever feasible in order to bring the "greatest protection to the greatest number" of fluid milk consumers. At the same time we should not be blind to the faults of pasteurization, but should work for their correction.

4. Greater attention to the problem of safeguarding milk supplies in small communities and rural sections.

5. Recognition and encouragement of the efforts of the dairy industry in building desirable qualities into milk; such as greater nutritional values, qualities which are influenced by factors that go beyond the strict limits of hygiene and sanitation. L.H.B.

238. Tuberculin Testing and the Courts. JAMES A. TOBEY, The Borden Co., New York. 25th Ann. Report of Intern. Assoc. Milk Sanitarians, p. 95, 1936.

The first court decision upholding the tuberculin test was handed down by the Supreme Court of Minnesota in 1896.

Since this first decision on tuberculin testing, the United States Supreme Court and the courts of last resorts in a number of states have sustained the validity of municipal ordinances or board of health regulations requiring the tuberculin testing of cattle and the freedom of cows from this disease.

A total of some 35 references to court decisions are cited. L.H.B.

FEEDS AND FEEDING

239. Biological Value of Casein as a Supplement to the Proteins of Barley in Ratios for Pigs. E. H. HUGHES, California Agr. Exp. Sta. Jour. Agr. Research, *55*, 6, p. 461, Sept. 15, 1937.

It was noted that young pigs grow slowly on a ration in which barley was the sole source of protein. Feeding experiments showed that the addition of commercial casein to this ration at the rate of 1.5 per cent about doubled the growth rate and increased the gains per unit of feed consumed. However, when commercial casein was washed free of lactoflavin its addition to the ration produced no better growth than the ration in which the proteins were furnished solely by barley. Supplementing of the barley action with lactoflavin was not tried. L.M.T.

HERD MANAGEMENT

240. Shorten the Barn Feeding. C. F. MONROE, Ohio Agr. Exp. Sta. Weekly Press Bull. *22*, 51, Feb. 24, 1938.

Dairymen can shorten the barn feeding period from 1 to 2 weeks by properly fertilizing some of their permanent pasture and turning their cows out earlier. W.E.K.

ICE CREAM

241. Which Test Gives the Most Accurate Fat Determination for Ice Cream. FORREST C. BUTTON, Rutgers Univ., New Brunswick, N. J. J. Milk Tech. *1*, 1, p. 30, Oct., 1937.

The author states that "there is still no agreement on the part of scientific workers as to the reliability of any of the modified fat tests for ice cream." L.H.B.

242. Ice Milk. F. W. MILNER. Ice Cream Field *31*, 2, p. 25, 3, p. 25, July-Aug. 1937.

The author gives the results of observations on the use of ice milk in milk shakes. In attempting to arrive at the most satisfactory basis of using ice milk in such drinks he prepared milk shakes by adding the same weight of ice milk which had been frozen so as to have widely different overruns.

It was found that the use of low overrun ice milk gave higher viscosity milk shakes than the use of high overrun ice milk even though the same weights were used in both cases. Also that the volume of the prepared drink was greater when low overrun ice milk was used in its preparation than when the same weight of high overrun ice milk was employed.

The author also reports comparative costs of milk shakes made with ice milk varying in overrun. W.C.C.

243. Quality Control in the Ice Cream Plant. H. F. JUDKINS, Sealtest System Lab., Inc., New York. 25th Ann Report of the Intern. Assoc. Milk Sanitarians, p. 290, 1936.

This paper discusses essential factors in the manufacture of high grade ice cream.

Plant, equipment, materials, manufacturing methods, personnel, etc., are included. L.H.B.

244. New Problems in Ice Cream Sanitation Committee Report. F. W. FABIAN, 25th Ann. Report of Intern. Assoc. Milk Sanitarians, p. 330, 1936.

This is a committee report and mention is made of some of the problems

confronting the Health Official regarding counter freezers, pasteurization, and sterilization of equipment. Also fountain sanitation is discussed.

L.H.B.

Other abstracts of interest are numbers 227, 230, 234, 237, 238, 245, 253, 262, and 263.

MILK

245. Investigation of the Amylase and Phosphatase Tests as an Indication of Pasteurization. F. W. Gilcreas and W. S. Davis, Div. of Lab. and Research, N. Y. State Dept. of Health, Albany, N. Y. 25th Ann. Report of Intern. Assoc. Milk Sanitarians, p. 16, Oct., 1936.

A study of the amylase test as described by Leahy made on 87 sample showed the test was accurate in 59 per cent of the cases in determining accurately the treatment received by the sample.

Conclusions were that the amylase test could not be relied on to detect accurately the degree of treatment.

The authors used and were much favorably inclined toward the Kay and Graham procedure for the phosphatase test. L.H.B.

246. Homogenization as a Preventive of Oxidized Flavor. Harold E. Ross, Cornell Univ., Ithaca, N. Y. Milk Plant Mo. *26*, 4, p. 36; 8, p. 40, April-May 1937.

Experimental evidence is presented showing the effectiveness of homogenization as a means of preventing the development of copper induced oxidized flavor in milk and cream. Low homogenization pressures of 500 and 1000 pounds per square inch were partially effective, but for positive results higher pressures were necessary. The development of the oxidized flavor was prevented entirely by homogenization at pressures of 1500 pounds per square inch and above. These pressures were equally effective in preventing the development of the off flavor when copper was added to the milk after homogenization.

Tables are presented giving details of all the experiments. The author advances a theory explaining in part why milk properly homogenized does not develop an oxidized flavor. G.M.T.

247. The Oxidized Flavor in Milk from the Individual Cow. C. D. Dahle and L. S. Palmer, Penn. Agr. Exp. Sta. Bul. 347, May, 1937.

The spontaneous oxidized flavor in milk is considered to be due to the oxidation of the phospholipid fraction of the fat globule membrane (lecithin) and the butterfat. It was determined that the enzyme-like factor responsible for off-flavor is carried in the plasma and serum portion of the milk, but that it is not responsible for the reduction of vitamin C content. The develop-

ment of oxidized flavor in milk is greatly inhibited by feeding green foods, incubation at 98° F., pasteurization above 168° F., the removal of oxygen or by the additions of vitamin C, hydroquinone, and oat flour. Pasteurization between 145–160° F. and exposure to sunlight enhance the off-flavor. Storage of susceptible samples at 40–45° F. caused a decrease in vitamin C content, but less in milks heated to 170° F. W.D.S.

248. Report of the Committee on Dairy Farm Methods. F. D. HOLFORD, 25th Ann. Report of the Intern. Assoc. Milk Sanitarians, p. 303, 1936.

This report discusses information an inspector should have, also the following fundamentals: general conditions, health of cows, utensils, milking, milk house and cooling. L.H.B.

249. Methods of Improving Milk Supplies in Small Communities. LESLIE C. FRANK, 25th Ann. Report of Intern. Assoc. Milk Sanitarians, p. 347, 1936.

This paper gives a very thorough report on the status of milk control in municipalities of 1000 to 10,000 population. L.H.B.

250. Milk Control in Small Communities on a Mandatory versus A Voluntary Basis. C. A. ABELE, State Dept. of Health, Montgomery. 25th Ann. Report of the Intern. Assoc. Milk Sanitarians, p. 382, 1936.

Gives reasons why he thinks milk control in small communities will prove more satisfactory on a voluntary basis and that this method has several distinct advantages over the policy of mandatory compliances. L.H.B.

251. Experiences in Meeting Milk Flavor Problems. C. L. ROADHOUSE, Univ. of California. 25th Ann. Report of Intern. Assoc. Milk Sanitarians, p. 201, 1936.

A discussion of normal constituents of milk influencing taste. The chloride-lactose relation is believed to be most concerned with the natural pleasant flavor of milk.

Feed flavors, rancidity, oxidized flavor, and influence of sunlight are also discussed. L.H.B.

252. The Influence of the Ration on Milk Flavor. J. A. ANDERSON, Bureau of Biol. Res., Rutgers, Univ., New Brunswick, N. J. 25th Ann. Report of the Intern. Assoc. Milk Sanitarians, p. 223–238, 1936.

Observations over a period of months on two large farms producing high grade milk indicated that certain food accessories of the feed had an important bearing on the flavor development in milk after two to four days of storage. In one herd very few cows produced milk which acquired an off

flavor on storage, while in the other many cows produced such milk. Both herds received approximately the same kind of feeds, however, the one wherein the least trouble with off flavor was experienced received machine cured alfalfa hay while the other herd was fed field cured alfalfa.

Other investigators have demonstrated that machine dried alfalfa contained approximately as much carotene as did fresh alfalfa, while three days of field curing caused a loss of nine tenths of the carotene.

Substituting field cured alfalfa for machine cured alfalfa in the ration of a cow giving rancid milk had a decided effect in increasing both the intensity and frequency of flavor development. Again feeding machine cured in place of field cured alfalfa again lessened this flavor development.

Carrots (2 to 3 times richer in carotene than fresh alfalfa) were also fed with excellent results in reducing rancid flavors.

Feeds rich in carotene were also found beneficial in preventing and lessening oxidized flavor developing in milk.

Feeds rich in vitamin C (fresh cabbage) had no beneficial effect in preventing oxidized flavors. L.H.B.

253. The Scope of the Milk Sanitation Studies of the Public Health Service. LESLIE C. FRANK, Office of Milk Investigations, U. S. Public Health Service, Washington, D. C. 25th Ann. Report of Intern. Assoc. Milk Sanitarians, p. 191, 1936.

During the past ten years the milk sanitation studies of the Public Health Service have included projects designed to answer the following questions:

1. How frequently do milk borne outbreaks of disease occeur?

Since 1923 an annual questionnaire has been sent to health officers of all municipalities of 10,000 population and over. These surveys indictae that the average for the past 10 years is at least 43.5 milk borne outbreaks per year.

2. To what extent do American communities attempt to control milk supplies, and to what extent are their citizens protected by such major measures as pasteurization, tuberculin testing, abortion testing, ets.?

From 1927 to 1931 in municipalities of 10,000 or over, pasteurization of milk supplies increased from 81.8 per cent to 87.5 per cent. Milk from tuberculin tested cows increased from 68.1 per cent to 88.7 per cent in the same periôd of time.

3. How can process of pasteurization be tested to determine whether they are effective, and how can the efficiency of various types of pasteurization be compared with each other.

No apparatus should be approved that shows a temperature deviation greater than 1° F. Tests conducted on 160° F. for 15 sec. and 142° F. for 30 minutes gave assurance that either method would prevent milk borne outbreaks of disease, however, no answer is available as to which of the two methods gives the greater factor of safety.

4. How can processes of germicidal treatment of dairy and milk plant equipment be tested to determine whether they are effective, and how can the efficiency of various processes be compared?

This question is being studied. Heat methods are being compared with chemical methods. Each chlorine compound is to be tested with a test organism to determine the number of parts per million required to produce a standard percentage killing of a standard concentration in a standard time, at a standard temperature, at a standard pH, and with a standard temperature, and with a standard concentration of organic matter.

5. How should pasteurizer inlet and outlet valves be designed?

Some of the results of this study are now contained in the Public Health Service Milk Code. A more detailed publication is contemplated.

6. Are air and foam heaters necessary and how should they be designed?

Milk foam is nearly always insufficiently pasteurized. A publication on these studies is contemplated.

7. What is the cost of strictly enforcing the Public Health Service Milk Ordinance?

The mean cost reported by 74 cities which were strictly enforcing the ordinance as shown by ratings of 90 per cent or higher, was 8.3 cents per capita per year or one-half cent per gallon.

8. Does pasteurization significantly affect the food value of milk?

This study was undertaken several years ago and the results for children ten months to six years of age showed that the growth promoting capacity of milk is not significantly affected by pasteurization or other heating.

9. What is the public health significance of keeping milk cold in the home?

This study has been completed and the publication is ready for distribution.

10. Can the Public Health Service milk ordinance be successfully applied to a very large city?

During the past ten years the ordinance has been adopted by larger and larger cities. In 1935 it was adopted by Chicago and a study of the progress is being closely made there. Studies to date seem to indicate the results will be successful. If so, this should finally settle the question as to whether the Public Health Service milk ordinance is sufficiently flexible to be adapted to population groups varying in size from less than 10,000 to more than 3,000,000. L.H.B.

254. A Study of Milk from Apparently Normal Udders. C. K. Johns, Central Exp. Farm, Ottawa, Canada. 25th Ann. Report of Intern. Assoc. Milk Sanitarians p. 145, 1936.

A study was made of heifers giving foremilk of abnormal composition from apparently normal udders.

High values for catalase, chlorides, and pH in the foremilk do not always indicate infection with mastitis streptococci or other specific pathogens.

A positive diagnosis should be based primarily on the demonstration of the causative organism. L.H.B.

255. Milk Control in Pennsylvania. WILBUR K. MOFFETT, State Dept. of Health, Harrisburg, Pa. 25th Ann. Report of Intern. Assoc. Milk Sanitarians, p. 165, 1936.

Pennsylvania revised its milk control law by the State Department of Health inviting the cooperation of the local health officers, the milk dealers, the ice cream manufacturers, the medical associations and any other organizations which were interested in health measures. We tried to take the best ideas from those used in New York, New Jersey and other states and incorporated them in the Pennsylvania regulations, known as Act 210, which was signed by the Governor, July 2, 1935.

We still have a system of approved inspectors but standards for these inspectors have been raised. There are about 350 of these approved inspectors and they are hired by the plants. To obtain a certificate as an approved inspector, they must have some technical training, some practical training, a lot of common sense, and good moral character, besides passing an examination which is not given out in advance. These men are supervised by 28 state inspectors.

Before milk, or any dairy product, or ice cream or any product that goes into ice cream can be sold in Pennsylvania, the dealer, at his own expense, must put in shape his own supply to meet the requirements of the state. After that is done, he makes an application. The state then sends men to check on the work of the approved inspector, and in case of new applications to do business in the state it means a 100 per cent check on every farm that is shipping to that plant. That means that all butter used in ice cream must come from an inspected source. Also all evaporated milk used in Pennsylvania must come from an inspected source.

All raw milk producers are inspected by the Department of Health and not by approved inspectors. L.H.B.

256. The Use of Resazurin in Determining the Bacterial Quality of Milk and Cream. J. N. WARNER, Iowa State College, Ames, Iowa. Dairy World *16*, 9, p. 18, Feb., 1938.

In a comparison of the resazurin test with the methylene blue test, utilizing methylene blue chloride and methylene blue thiocyanate and reading the resazurin tests at the violet, pink and white stages, the following conclusions were drawn. The resazurin test offers no advantage over the methylene blue if resazurin-white is used as the end point. The resazurin-pink and resazurin-violet reduction times are considerably shorter than the methylene blue but classification of samples does not parallel the latter test. Whether the difference would result in a more desirable classification or a less desirable classi-

fication is not shown in the data obtained. The resazurin test showed no advantage over the methylene blue test for use with pasteurized milk or cream or ice cream mix. F.J.D.

257. Some Factors Affecting the Accuracy of the Babcock Test on Composite Samples of Milk. C. W. ENGLAND AND G. D. D'AMBROGI, Univ. of Maryland, Agr. Exp. Sta., College Park, Md. Bull. 413, Oct., 1937.

Composite samples of milk were prepared by making daily additions of 10.4 ml. each. Those samples were held for seven, ten and fifteen days at 45°, 60°, 80° and 100° F. and were preserved by one mercuric chloride tablet (0.48 gram tablet containing 46.66 per cent $HgCl_2$). Composite samples were also prepared with one-half, one and two mercuric chloride tablets and held at 60° and 100° F. for seven, ten and fifteen days. Fresh samples were tested daily and their average test compared with the tests of all composite samples.

Samples of milk were brought to a definite volume by adding 156 ml. to each sample bottle, the sample then being tested immediately for fat content. These samples were held at 45°, 60°, 80° and 100° F. for seven, ten, and fifteen days, and were preserved by one mercuric chloride tablet. Samples brought to a constant volume were also preserved with one-half, one, and two mercuric chloride tablets and held at 60° and 100° F. for seven, ten, and fifteen days. The fresh sample tests were compared with the tests of all preserved samples.

All tests were made by the Babcock Method. A summary of results follows:

1. The fat tests on all composite and preserved sample, regardless of the length of time held, averaged lower than the fresh sample average test. As the time of holding is increased the resulting fat test is decreased.

2. The fat tests on all composite and preserved samples, regardless of the temperature held, averaged lower than the fresh sample average test. As the temperature of holding is increased, the resulting fat test is decreased.

3. Samples preserved by one mercuric chloride tablet gave the highest, one-half tablet the next highest, and two tablets the lowest fat tests. This holds true for all periods of time at both 60° and 100° F. Regardless of the amount of mercuric chloride used, all tests on composite and preserved samples were lower than the fresh sample test.

The average of all fresh sample tests was 4.355 per cent. The average test of all composite and preserved samples held for seven and ten days at 45° and 60° F. using one mercuric chloride tablet was 4.302 per cent. Thus it may be stated that when preserved samples were held under excellent conditions, the fat test averaged 0.053 per cent lower than the true fresh sample test.

The average test of all composite and preserved samples held for fifteen

days at 45° and 60° F. using one mercuric chloride tablet was 4.275 per cent, or 0.080 per cent lower than the true fresh sample average.

The average test of all composite and preserved samples held at 80° and 100° F. using the mercuric chloride tablet was 4.188 per cent, or 0.167 per cent lower than the true fresh sample average. C.W.E.

258. Salvaging Return Milk. ANONYMOUS. Milk Dealer 27, 4, p. 44, Jan. 1938.

A brief summary of how some dealers, in localities which permit milk to be returned to the routes the second day, are eliminating the loss on returns by the use of refrigerated delivery trucks. A cross section of replies received from various sections of the country regarding the use of returns is also given. C.J.B.

259. Report of the Committee on the Food Value of Milk and Milk Products. G. C. SUPPLEE, Bainbridge, N. Y. J. Milk Tech, *1*, 1, p. 16, Oct. 1937.

A brief summary of the findings of various investigators on factors effecting the food value of milk. L.H.B.

260. Engineering of Pasteurization. C. A. HOLMQUIST AND W. D. TIEDEMAN, State Dept. of Health, Albany, N. Y. J. of Milk Tech. *1*, 1, p. 11, Oct. 1937.

Some of the faults of old type pasteurizers are cited, and how these have been eliminated by dairy engineers in testing, and redesigning equipment so that equipment is now available that will pasteurize milk with a full factor of safety. L.H.B.

261. The Resazurin Test—Preliminary Studies on Its Practicalities and Possibilities. J. A. KEENAN, W. D. BARRETT, AND H. RUTAN, Whiting Milk Co., Boston, Mass. J. of Milk Tech. *1*, 1, p. 22, Oct., 1937.

The authors concluded that the resazurin test will impart more information concerning the quality of milk in one hour's incubation than will the methylene blue test in six hours' incubation.

The test is more sensitive to abnormal milks (colostrum and mastitis milks) than is the methylene blue test. L.H.B.

Other abstracts of interest are numbers, 225, 230, 233, 234, 235, 236, 237, 238, 262, 263, and 264.

MISCELLANEOUS

262. Report of Committee on Milk Plant Practice. A. R. TOLLAND, 25th Ann. Report of Intern. Assoc. Milk Sanitarians, p. 181, 1936.

With but one exception all members of the committee replying on the question of bottling orange juice in milk plants the practice should be forbidden. A number of states and cities require that orange drinks be processed in equipment (or rooms) not used for handling fluid milk.

Reconstructed dairy orange beverages rapidly lost their vitamin C content on standing at room temperature. The loss at cold storage temperature is much less but is still considerable. L.H.B.

263. Vitamin C Content of Dairy Orange Beverages. M. J. MACK, C. R. FELLERS, W. A. MACLINN AND D. A. DEAN, Mass. Agr. Exp. Sta., Amherst, Mass. 25th Ann. Report of the Intern. Assoc. of Milk Sanitarians, p. 267, 1936.

Chemical methods for determining vitamin C content of orange beverages were found to agree closely with the biological assay method.

Twelve samples of ten different dairy orange beverages were found to contain from 0.2 to 53.0 units of vitamin C per ounce.

Fresh orange juice contained 228 to 258 units per ounce; while canned orange juice had slightly over 200 units per ounce.

Reconstituted dairy orange beverages lose their vitamin C very rapidly at room temperature, usually about 60 per cent in 20 hrs. At 40° F. the loss was 15 per cent or more in the same time. In two days the loss was even greater; yet many dairies do not make up the product daily. L.N.B.

264. The Physician and Our Daily Bread. American Institute of Baking, 9 Rockefeller Plaza, New York, N. Y. Pp. 19, 1938.

Although this booklet is devoted to the subject of bread and its proper place in normal and reducing diets, there are many allusions to milk in it. Thus, it is stated that practically all white bread now contains at least 6 per cent skimmilk solids, which enhance the nutritive properties of the loaf by adding proteins, minerals, and certain vitamins. Several pages of sample daily menus for use in reducing diets are prefaced by the statement that "a pint of certified or pasteurized milk, or its equivalent in other dairy products, is desirable in all daily reducing diets." Bread is recommended in these diets as a necessary source of the carbohydrate needed for the most efficient burning of body fat. This pamphlet is accepted by the Council on Foods of the American Medical Association. J.A.T.

Another abstract of interest is number 235.

PHYSIOLOGY

265. Fat Feeding and Cholesterol Absorption. ROBERT PERCIVAL COOK, Biochem. Lab., Cambridge, England. Biochem. J. *31*, 410, 1937.

In a previous study it was observed that with growing rats cholesterol is absorbed only in the presence of free fat in the diet, a cholesterol "fatty" liver being induced solely under these conditions. In this study the experiments were conducted to determine the effect of the amount of fat on cholesterol absorption. Growing rats were fed on diets containing 15, 20 and 30 per cent fat (arachis oil) with and without 2 per cent cholesterol. Cholesterol was observed to have a deleterious effect on the growth rate, which was most marked with the 15 per cent fat diet. This affect is, during the first few weeks probably due to the reduced food intake of the animals, after which period the rats adapt themselves to the ration. The absorption of cholesterol is not increased by raising the fat concentration in the diet. Approximately 30 per cent of the cholesterol fed remains unaccounted for, as determined by unsaponifiable fractionation of the faeces and the animals' bodies.

K.G.W.

266. A Study of the Effect of Overfeeding on the Protein Metabolism of Man. I. The Effect of Superimposing Raw and Boiled Milks on a Diet Adequate for Maintenance. II. The Superimposition, on a Diet Adequate for Maintenance, of Beef (or Soya Flour) Plus Lactose Plus Butter, Equivalent in Protein, Carbohydrate and Fat Content to a Liter of Milk. D. P. Cuthbertson, Alexander McCutcheon and H. N. Munro, Institute of Physiology, Univ. of Glasgow, Scotland. Biochem. J. *31*, 681, 1937.

Seven subjects of good physique, members of the teaching or laboratory staff, were given self-selected basal diets including 500 ml. raw milk, with a constant water intake. After the nitrogen equilibrium had been determined for each of the subjects, the diet was superimposed by one liter of either raw or boiled milk. This was conducted both in one day and 8 day tests. Superimposition of a liter of either raw or boiled milk on the diet, adequate for maintenance of body weight and nitrogen equilibrium in the adult human subject, caused an increase in body weight and a marked retention of nitrogen and sulphur but not of calcium. No significant difference could be observed in the metabolic fates of the proteins of raw and boiled milks. When sodium caseinate equivalent in nitrogen to the added liter of milk was substituted in the diet of one subject, the retention of nitrogen was definite, but not of the same magnitude as for milk.

The superimposition of beef plus lactose plus butter equivalent in protein, carbohydrate and fat content to a liter of milk also effected a definite saving of food nitrogen. Soya flour plus lactose plus butter gave similar results.

K.G.W.

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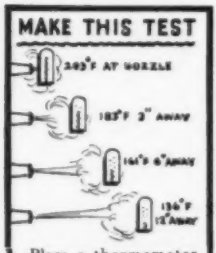
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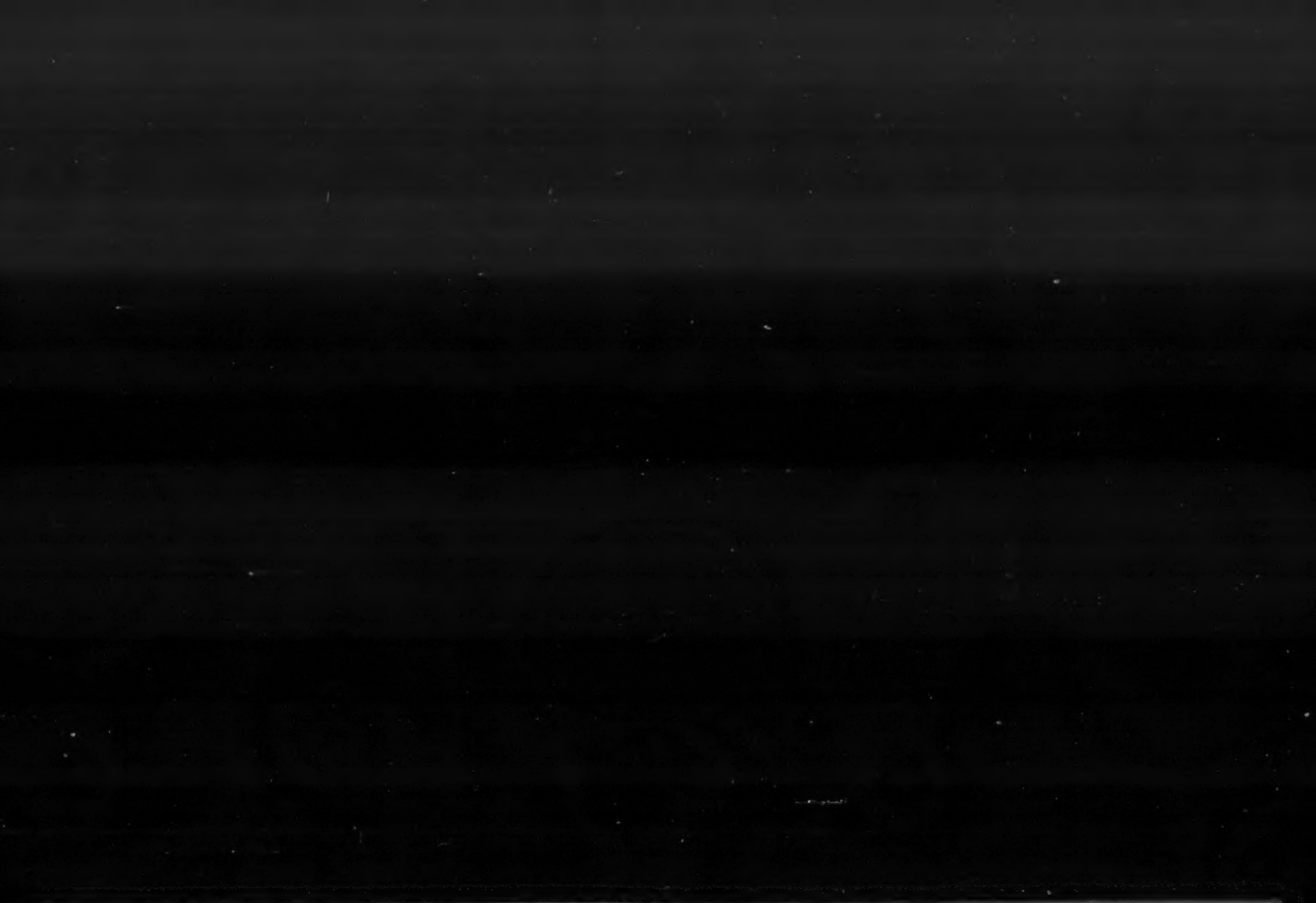

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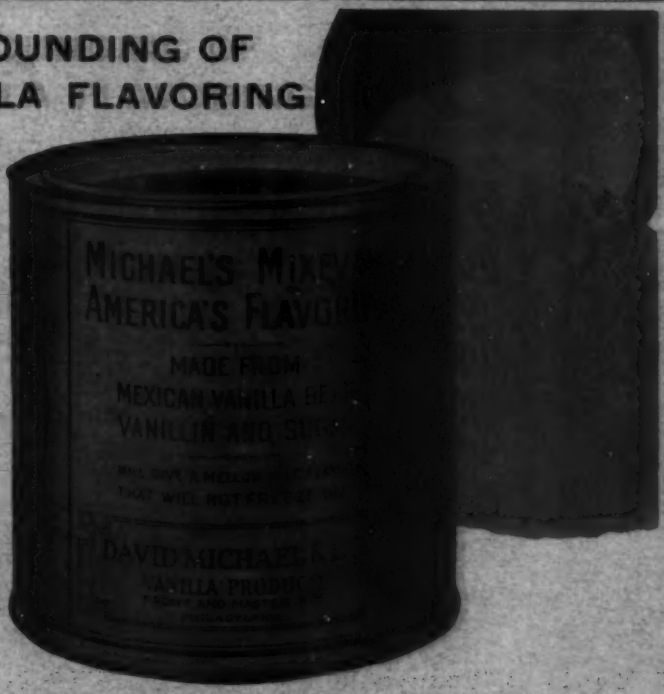

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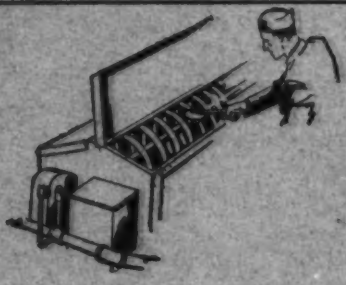

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